SCIENCE

21 November 1958

Volume 128, Number 3334

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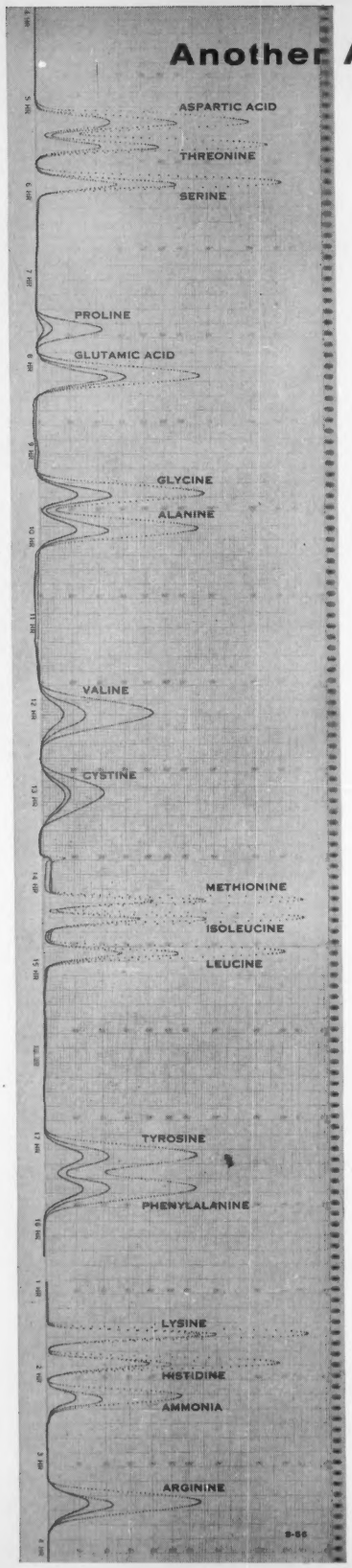

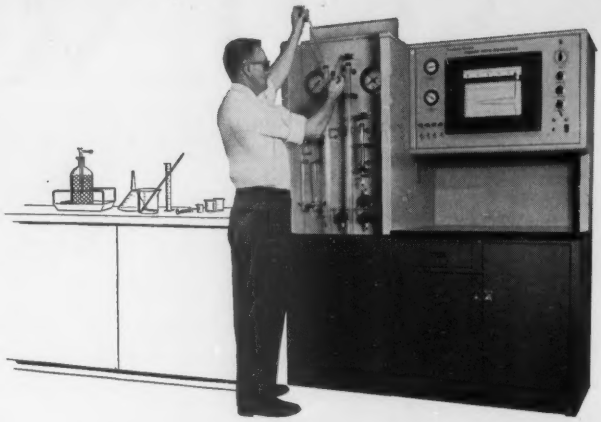

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Reference: *D. H. Spackman, W. H. Stein, and S. Moore, "Automatic Recording Apparatus for use in the Chromatography of Amino Acids", Anal. Chem., 30, 1190-1206, 1958.*

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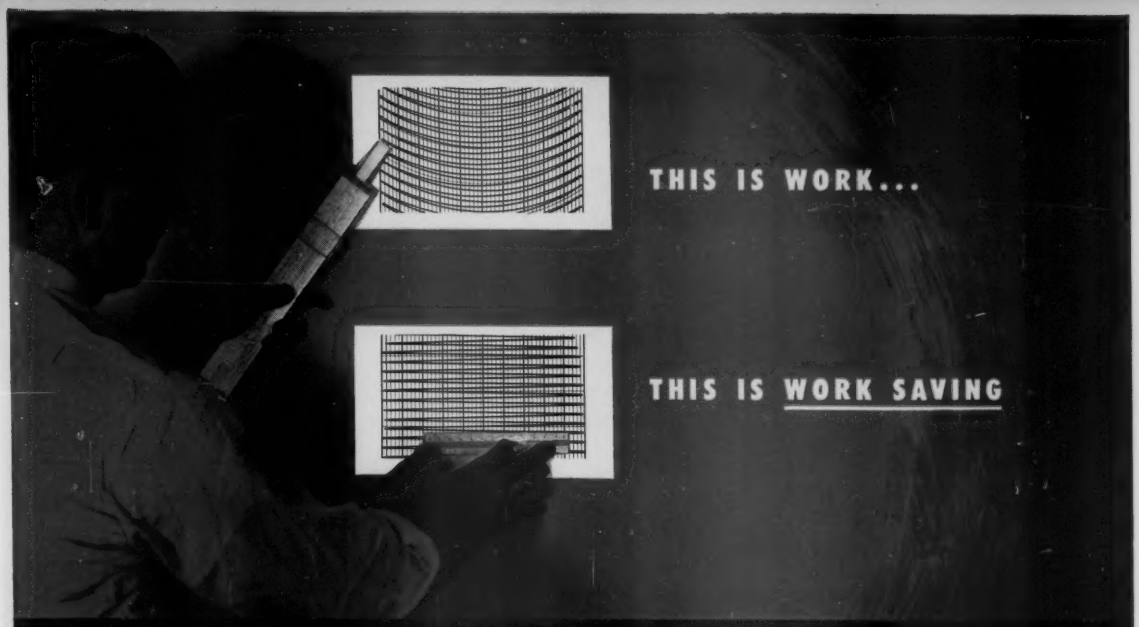

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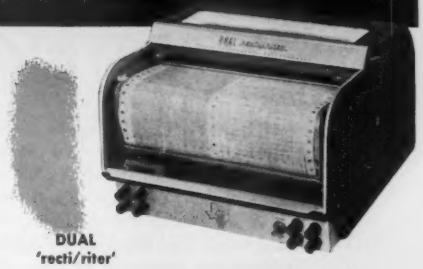
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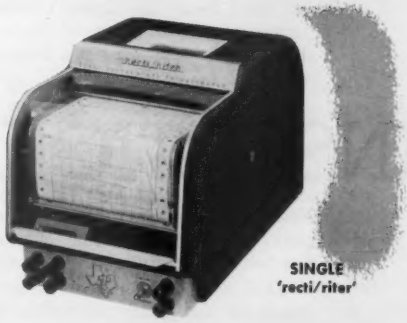
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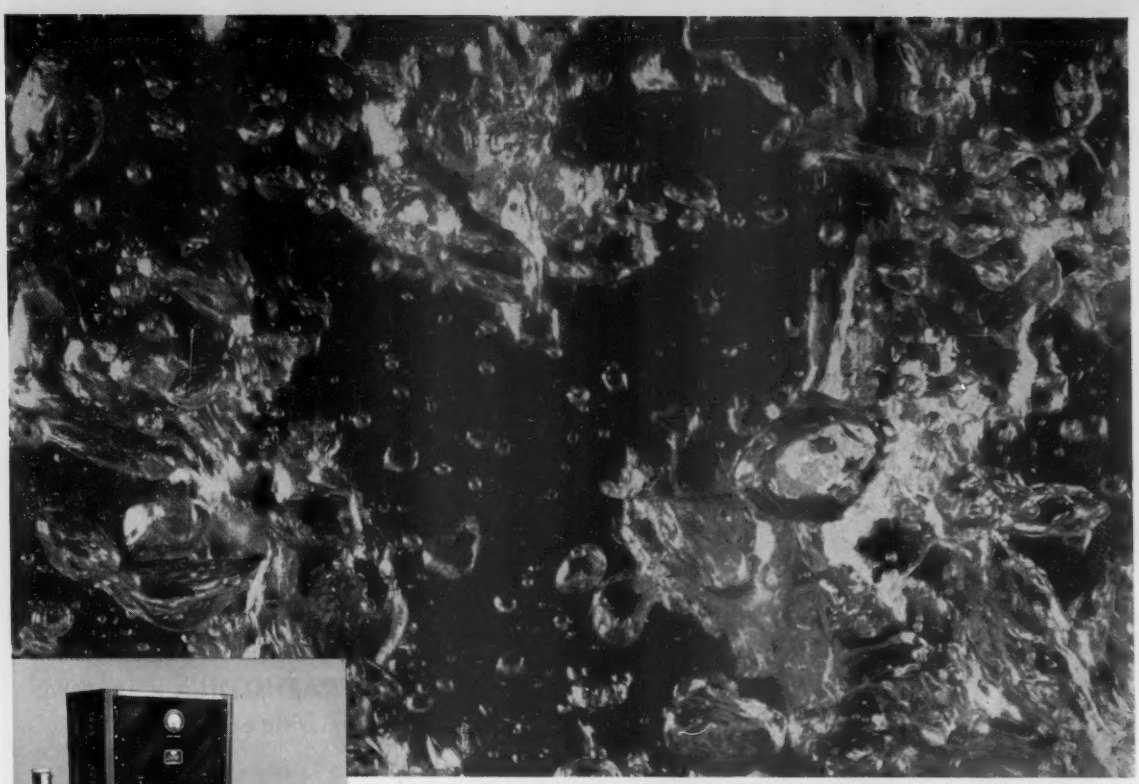

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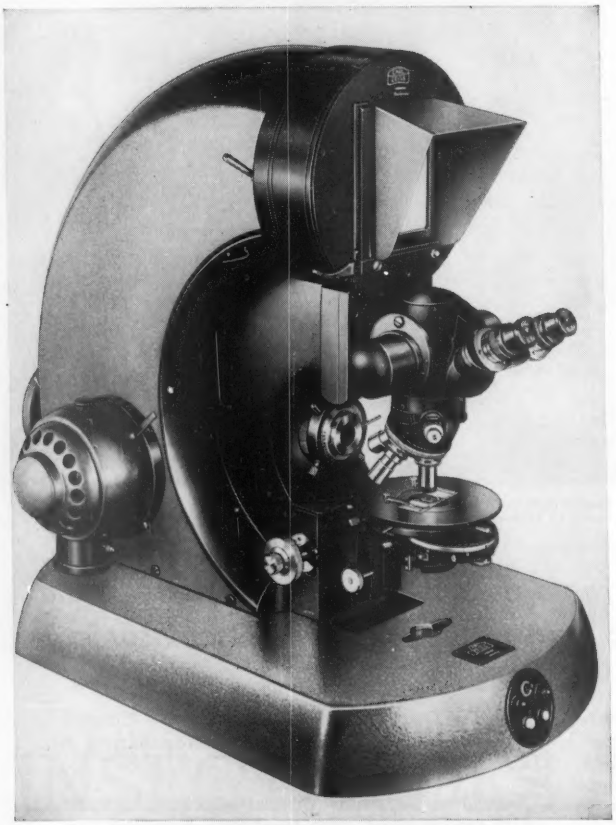

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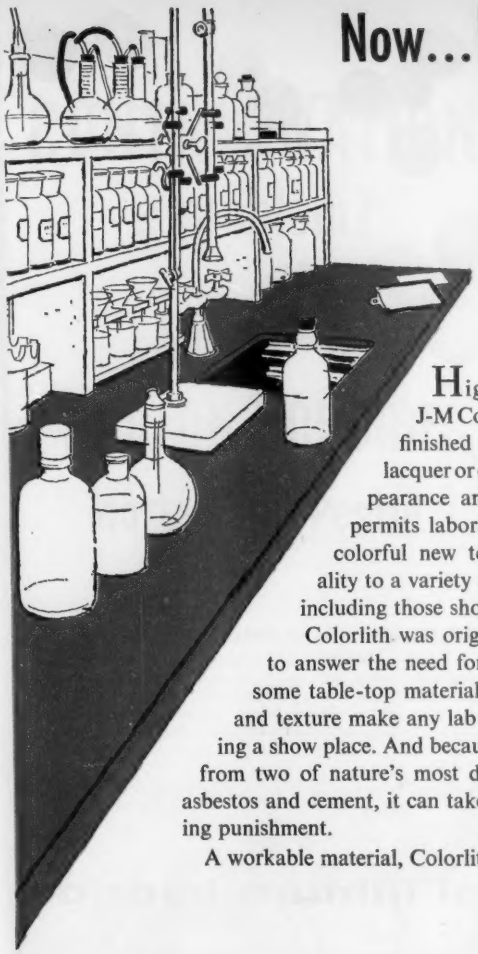

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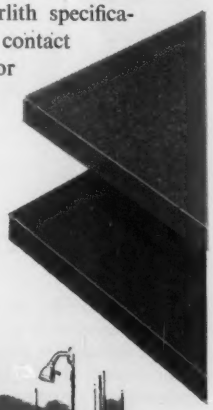

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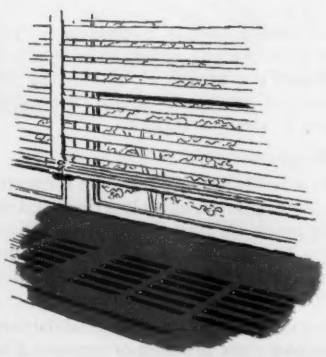

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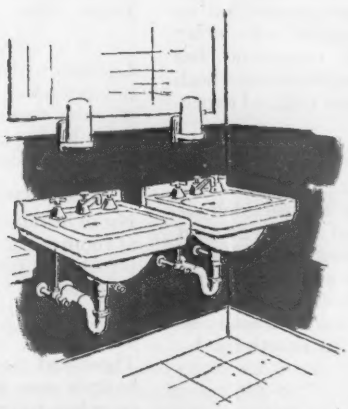

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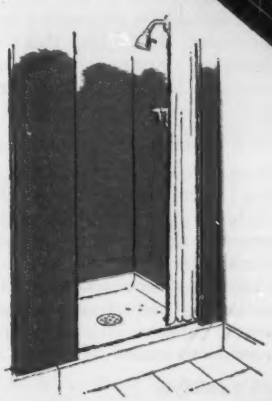

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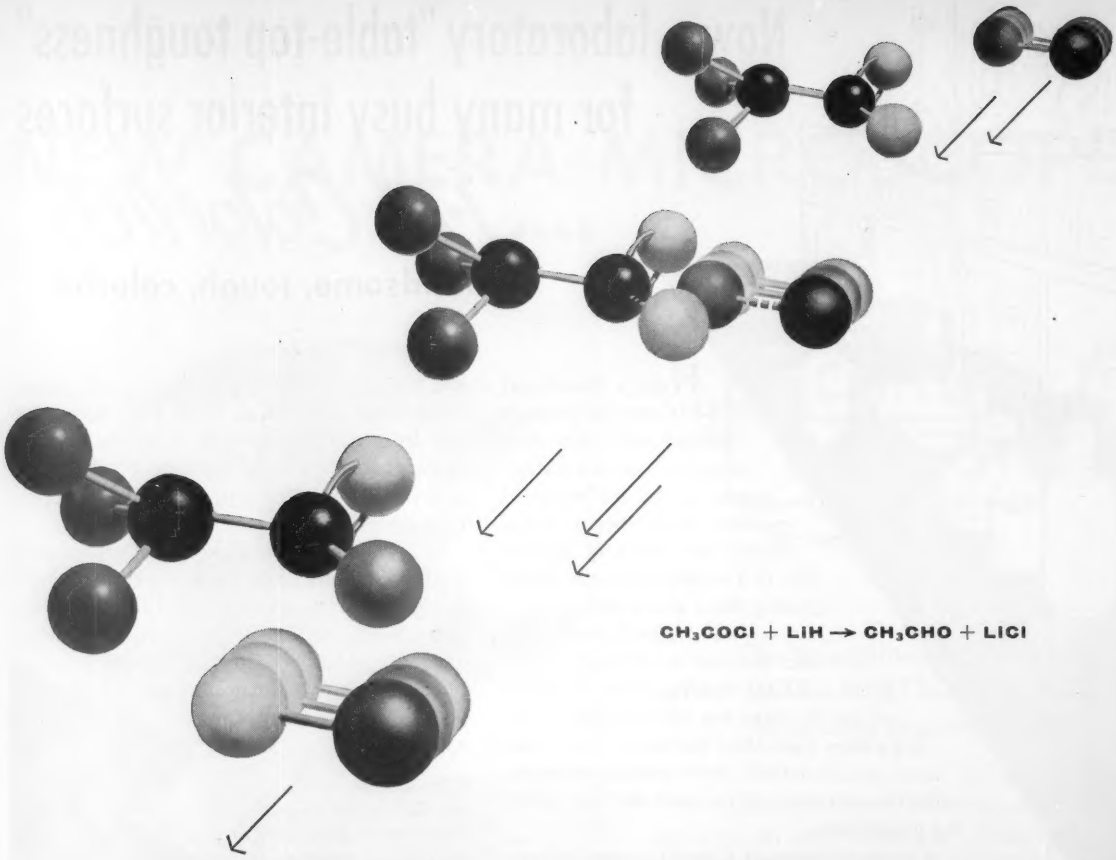

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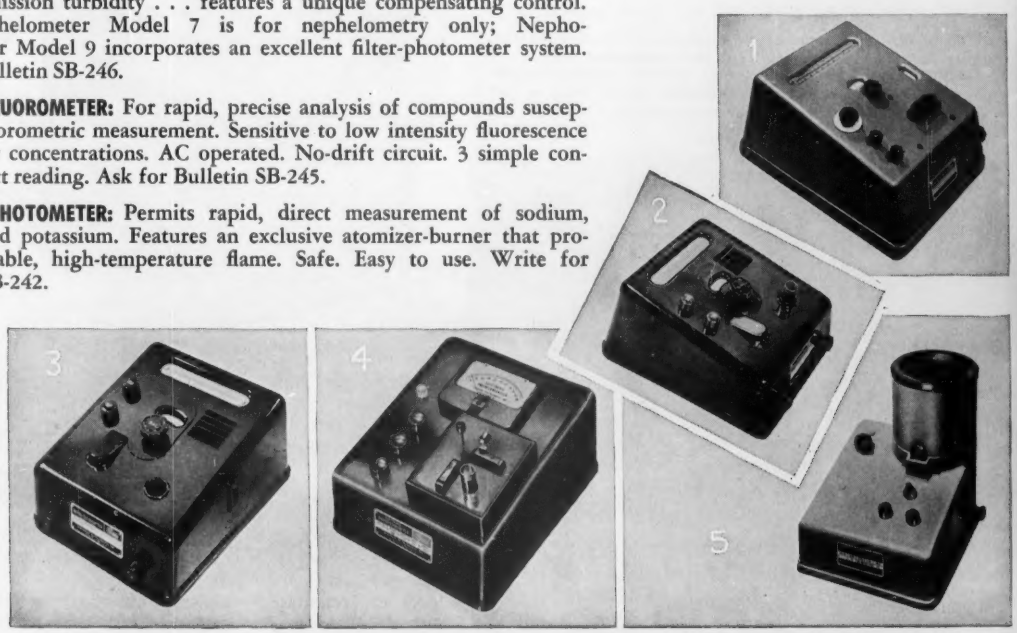

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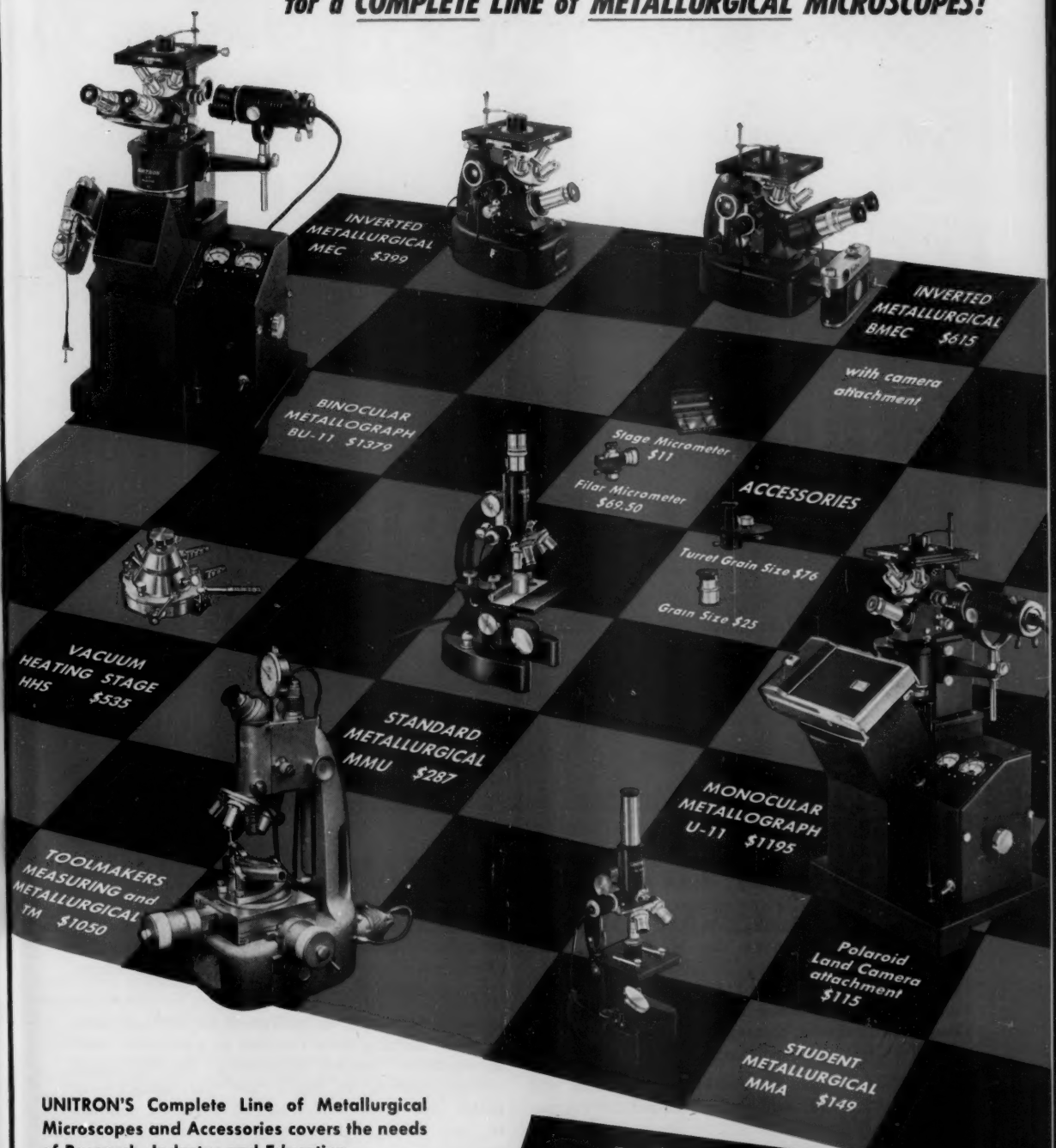

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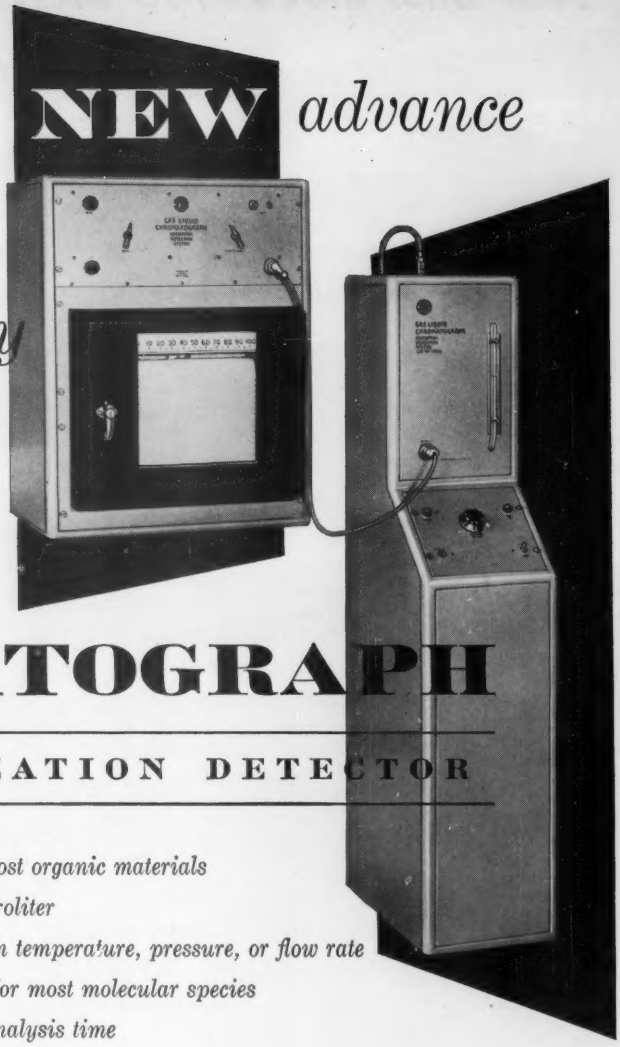

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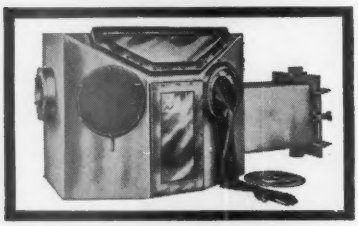

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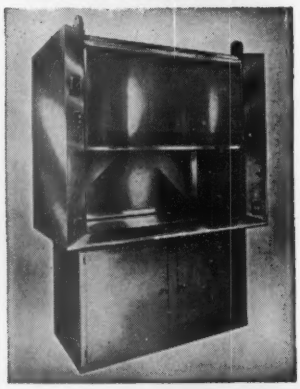

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Letters

Culturology

It may be of interest to readers of *Science* to learn that *Webster's New International Dictionary of the English Language* has included, in the addenda to the second edition (1954), the new name of a moderately old science—namely, *culturology*.

The science of culture (dealing with customs, institutions, beliefs, languages, arts, tools, and so on—in short, those characteristics which distinguish the human species from all others) was first defined, and its scope was first outlined, by the eminent English anthropologist Edward Burnett Tylor (1832–1917), in "The science of culture," the first chapter of his great work, *Primitive Culture* (1871). The scientific study of customs, beliefs, languages, and artifacts, both modern and prehistoric, has, of course, been the chief occupation of many cultural anthropologists—ethnologists and archeologists—since Tylor's day, and even long before.

But much of the work of anthropologists is not concerned with culture at all, but with the fossil remains, bones, muscles, genes, physiological processes, and so on, of men and other primates. And many "cultural" anthropologists have occupied themselves with nonculturological, psychological, psychoanalytic, and sociological (focusing upon social interaction among human beings) problems. The need arose, therefore, for a term that would distinguish the science of culture from other kinds of studies carried on by anthropologists. *Culturology* suggested itself in the tradition of scientific nomenclature that has produced *mammalogy, parasitology, mineralogy,* and so on.

Culturology was introduced into anthropological literature in 1939 in an article of mine, "A problem in kinship terminology" [*Am. Anthropologist* **41**, 571 (1939)]. It was given greater currency in 1949 in my book *The Science of Culture*. The first person to use this term, however, as far as is known, was a distinguished German chemist, philosopher, and Nobel prize winner, Wilhelm Ostwald (1853–1932), in *Energetische Grundlagen der Kulturwissenschaft* [(Leipzig, 1909), p. 112]. Later, in "The system of the sciences" [*Rice Inst. Pam.* **2**, No. 3 (1915)], he defined this concept more fully [see L. A. White, *The Science of Culture* (1949), pp. 113–117; 409–415]. I did not discover Ostwald, however, until 1949, some 15 years after I had begun to use *culturology* in my lectures.

The term *culturology* has encountered adverse criticism and opposition. Among other things, it has been called "a barbarism," an epithet applied in years gone by to *sociology* by some of Herbert Spencer's friends in an attempt to dissuade him from using this word (see H. Spencer, *Principles of Sociology*, vol. 1, preface). By "barbarism" they were alluding to the fact that *sociology* is derived from both Greek and Latin sources—as is *culturology*—and this, according to the late V. Gordon Childe, is something that one reared on *litterae humaniores* finds objectionable. But, over the years, *sociology* won acceptance and has now become commonplace. Also, the English language itself has been quite hospitable to hybrids of Greek and Latin derivation, such as *penology, dictaphone, television, jurist, socialist, deist, scientist, petroleum,* and *cablegram*.

Because *culturology* is so apt, specific, and precise; because it is homologous with other names of sciences (for example, *parasitology*); because the English language has a genius for assimilating newly coined words (for example, *dictaphone*); and, finally, because *culturology* is needed to distinguish the science of culture from psychological and sociological studies of human beings, its general acceptance and use may be confidently expected. *Culturology* was included in the *Dictionary of Anthropology* (New York, 1956) by Charles Winick, and one finds it occasionally in anthropological writings. Instances of its use will undoubtedly multiply in the future.

LESLIE A. WHITE
Department of Anthropology, University of Michigan, Ann Arbor

Names for Binary Numbers

The reading of "A system of names for binary numbers" in a recent issue of *Science* [**128**, 594 (1958)] impels me to describe another system devised some 6 or 7 years ago by the late D. A. Flanders, in line with some suggestions made by J. W. Givens. At that time the AVIDAC for the Argonne National Laboratory and the ORACLE for the Oak Ridge National Laboratory were both in the early stages of their construction, and we felt some concern for the problem of becoming familiar with their arithmetic to the base 2. In more practical terms, it was a question of getting used to the base 16, since it was convenient to group the binary digits together into tetrads.

The Givens-Flanders system was simplicity itself: Vowels and consonants were selected, each to represent one of the four binary pairs according to the following scheme:

n	o	0 0
k	a	0 1
r	e	1 0
s	i	1 1

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(*Continued on page 1298*)

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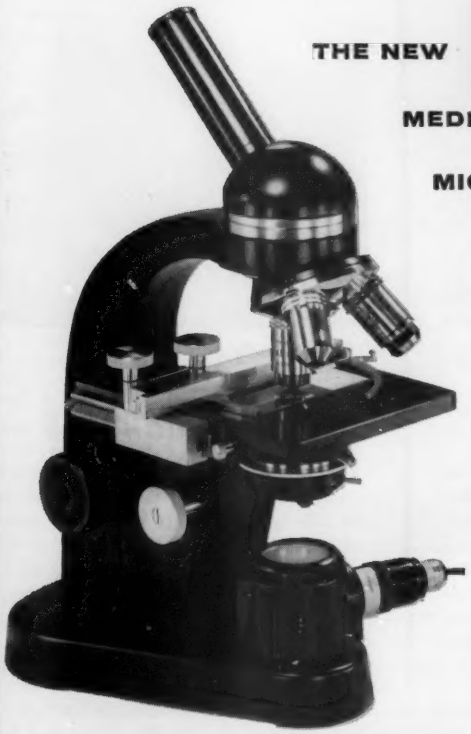

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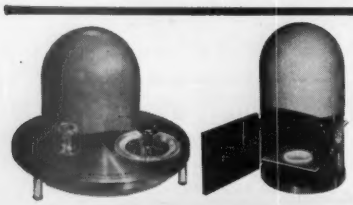

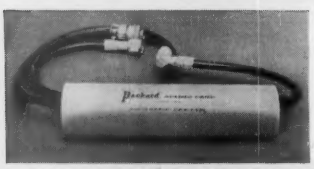

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When in Moscow

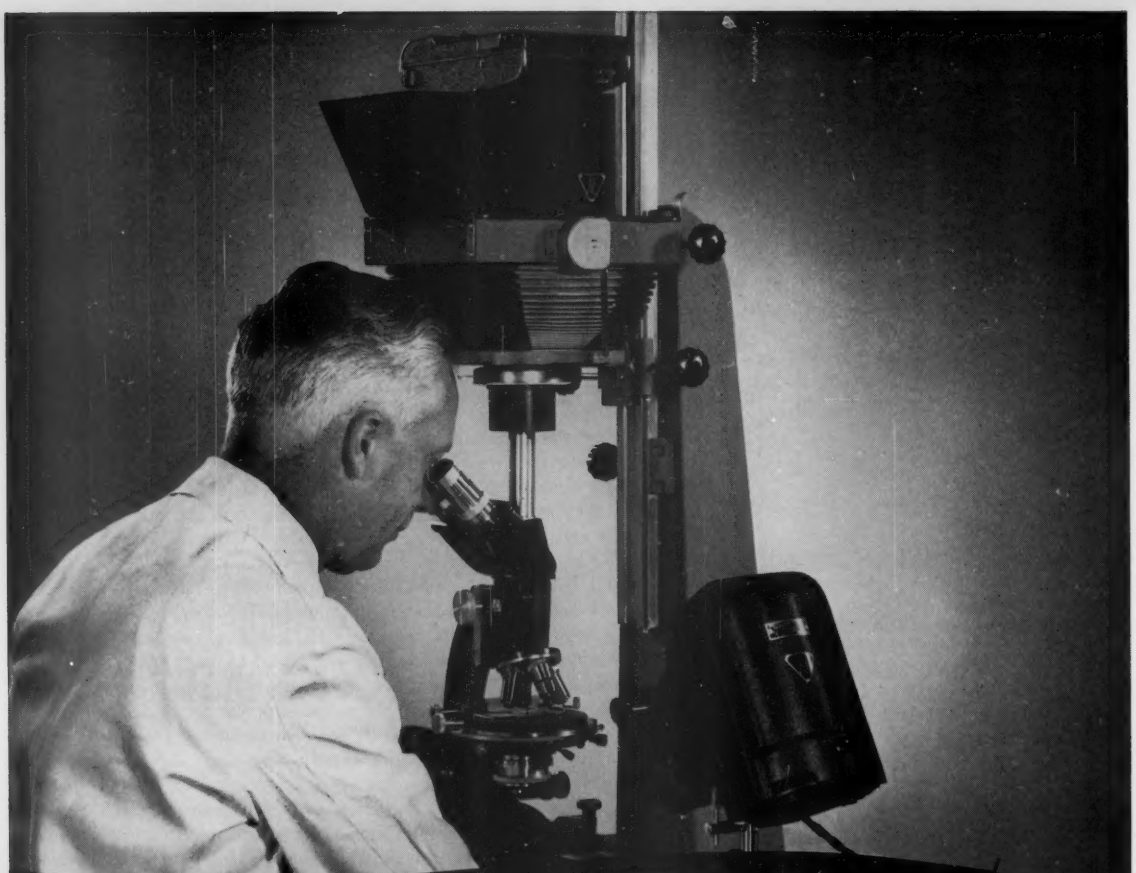
Although in most fields the International Geophysical Year is producing a remarkable record of data exchange, in the rocket and satellite field the Soviets have not been as free with their data as we should like, nor as we have been with ours. The IGY program is coming to an end at the close of this year, but other exchange programs are in the offing, including a follow-up of some uncompleted IGY activities under the title of International Geophysical Cooperation—1959. It is time, therefore, to consider how best to promote exchange in those areas in which it is not yet fully satisfactory.

In rocket and satellite research the principal stumbling block in dealing with the Soviets has been their refusal to agree to the same kind of automatic exchange of basic data that has been instituted in other research fields. To the best of this country's knowledge, the Soviets have kept the formal agreements that they have made concerning the exchange of results in rocket and satellite research. But although these agreements provide for the release of such items as news of the successful launching of satellites, they make it necessary for persons seeking information in other matters to negotiate each request separately. Coupled with this mechanism, or lack of one, for handling exchange is the unfortunate way the Soviets tend to deal with those requests that they do not wish to honor. Their pattern is to ignore the request or to talk about something else.

An example of answer by evasive tactics occurred when American scientists tried to visit the Soviet orbit computing center during the IGY conference in Moscow last summer. The center had been mentioned in a *Pravda* article announcing the launching of Sputnik III. The American scientists felt justified in seeking to make this visit since in September 1957 Soviet scientists had visited the Vanguard computing center. After some jockeying, arrangements for the visit were concluded. But when the appointed day arrived, the Americans found themselves inspecting not the orbit computing center but instead an institute for computer development.

When we are faced with shortcomings in the exchange of scientific information, our problem is how to respond in a way that will serve science and at the same time help science serve international good will. There are good reasons for us to be patient in our approach. For one thing, the feeling among American scientists is that by and large the Soviet scientists are as anxious as we are to participate in the exchange of data. For another, if in all areas the Soviets do not fully meet the conditions of exchange that we seek, still such conditions are now better than they have been in the past. A third reason is that it is possible that the evasive replies of the Soviets to some of our requests for information may be the result of a security system that in certain areas does not permit them to admit even the existence of a given piece of research.

But if patience is required in developing data exchange, then something more than a passing measure of toughness is also called for. The record of East-West relations does not suggest that an attitude of unalloyed politeness is the best way to do business with the Soviet Union. To the extent that the exchange of scientific results may have a bearing on nonscientific matters, it is difficult to see why, without considerable prodding, the Soviets will forego any arrangement that allows them to keep their cake and eat ours too.—J.T.



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21 November 1958, Volume 128, Number 3334 SCIENCE

Salt and Silt in Ancient Mesopotamian Agriculture

Progressive changes in soil salinity and sedimentation contributed to the breakup of past civilizations.

Thorkild Jacobsen and Robert M. Adams

Under the terms of a farsighted statute, 70 percent of the oil revenues of the Iraqi Government are set aside for a program of capital investment which is transforming many aspects of the country's predominantly agricultural economy. As compared with the subsistence agriculture which largely has characterized Iraq's rural scene in the past, new irrigation projects in formerly uninhabited deserts are pioneering a rapid increase in land and labor productivity through crop rotation, summer cultivation in addition to the traditional winter-grown cereals, and emphasis on cash crops and livestock.

But these and similar innovations often have disconcerting effects in a semiarid, subtropical zone—effects which cannot be calculated directly from the results of experiment in Europe and America. At the same time, old canal banks and thickly scattered ruins of former settlements testify to former periods of successful cultivation in most of the desert areas now being reopened. The cultural pre-eminence of the alluvial plains of central and southern Iraq through much of their recorded history provides still further evidence of the effectiveness of the traditional agricultural regime in spite of its prevailing reliance on a simple system of fallow in alternate years. Accordingly, the entire 6000-year record of irrigation agriculture in the Tigris-Euphrates flood plain furnishes an indispensable background for formulating plans for future development.

At least the beginnings of a comprehensive assessment of ancient agriculture recently were undertaken on behalf of the Government of Iraq Development Board. In addition to utilizing ancient textual sources from many parts of Iraq which today are widely scattered in the world's libraries and museums, this undertaking included a program of archeological field work designed to elucidate the history of irrigation and settlement of a portion of the flood plain that is watered by a Tigris tributary, the Diyala River (*1*). Here we cannot report all the diverse findings of the project and its many specialists, but instead will outline some aspects of the general ecological situation encountered by agriculturalists in the Mesopotamian alluvium which seem to have shaped the development of irrigation farming. And, conversely, we hope to show that various features of the natural environment in turn were decisively modified by the long-run effects of human agencies.

Historical Role of Soil Salinization

A problem which recently has come to loom large in Iraqi reclamation planning is the problem of salinity. The semiarid climate and generally low permeability of the soils of central and southern Iraq expose the soils to dangerous accumulations of salt and exchangeable sodium, which are harmful to crops and soil texture and which can eventually force the farmer off his land.

For the most part, the salts in the alluvial soils are presumed to have been carried in by river and irrigation water from the sedimentary rocks of the northern mountains. In addition, smaller quantities may have been left by ancient marine transgressions or borne in by winds from the Persian Gulf. Beside the dominant calcium and magnesium cations, the irrigation water also contains some sodium. As the water evaporates and transpires it is assumed that the calcium and magnesium tend to precipitate as carbonates, leaving the sodium ions dominant in the soil solution. Unless they are washed down into the water table, the sodium ions tend to be adsorbed by colloidal clay particles, deflocculating them and leaving the resultant structureless soil almost impermeable to water. In general, high salt concentrations obstruct germination and impede the absorption of water and nutrients by plants.

Salts accumulate steadily in the water table, which has only very limited lateral movement to carry them away. Hence the ground water everywhere has become extremely saline, and this probably constitutes the immediate source of the salts in Iraq's saline soils. New waters added as excessive irrigation, rains, or floods can raise the level of the water table very considerably under the prevailing conditions of inadequate drainage. With a further capillary rise when the soil is wet, the dissolved salts and exchangeable sodium are brought into the root zone or even to the surface.

While this problem has received scientific study in Iraq only in very recent years, investigation by the Diyala Basin Archeological Project of a considerable number and variety of ancient textual sources has shown that the process of salinization has a long history. Only the modern means to combat it are new: deep drainage to lower and hold down the water table, and utilization of chemical amendments to restore soil texture. In spite of the almost proverbial fertility of Mesopotamia in antiquity, ancient control of the water table was based only on avoidance of overirrigation and on the practice of weed-fallow in alternate

Dr. Jacobsen is a professor in the Oriental Institute, University of Chicago. Dr. Adams is an assistant professor in the department of anthropology and a research associate in the Oriental Institute, University of Chicago.

years. As was first pointed out by J. C. Russel, the later technique allows the deep-rooted *shoq* (*Proserpina stephanis*) and *agul* (*Alhagi maurorum*) to create a deep-lying dry zone against the rise of salts through capillary action. In extreme cases, longer periods of abandonment must have been a necessary, if involuntary, feature of the agricultural cycle. Through evapotranspiration and some slow draining they could eventually reduce an artificially raised water table to safe levels.

As to salinity itself, three major occurrences have been established from ancient records. The earliest of these, and the most serious one, affected southern Iraq from 2400 B.C. until at least 1700 B.C. A milder phase is attested in documents from central Iraq written between 1300 and 900 B.C. Lastly, there is archeological evidence that the Nahrwan area east of Baghdad became salty only after A.D. 1200.

The earliest of these occurrences particularly merits description, since it sheds light on the northward movement of the major centers of political power from southern into central Iraq during the early second millennium B.C. It seems to have had its roots in one of the perennial disputes between the small, independent principalities which were the principal social units of the mid-third millennium B.C. Girsu and Umma, neighboring cities along a watercourse stemming from the Euphrates, had fought for generations over a fertile border district. Under the ruler Entemenak, Girsu temporarily gained the ascendancy, but was unable to prevent Umma, situated higher up the watercourse, from breaching and obstructing the branch canals that served the border fields. After repeated, unsuccessful protests, Entemenak eventually undertook to supply water to the area by means of a canal from the Tigris; access to that river, flowing to the east of Girsu, could be assured without further campaigning against Umma to the northwest. By 1700 B.C. this canal had become large and important enough to be called simply "the Tigris," and it was supplying a large region west of Girsu that formerly had been watered only by the Euphrates. As a result, the limited irrigation supplies that could be drawn from the latter river were supplemented with copious Tigris water. A corresponding increase undoubtedly occurred in seepage, flooding, and overirrigation, creating all the conditions for a decisive rise in groundwater level.

Several parallel lines of evidence allow the ensuing salinization to be followed quantitatively:

1) Beginning shortly after the reign of Entemenak, the presence of patches of saline ground is directly attested in records of ancient temple surveyors. In a few cases, individual fields which at that time were recorded as salt-free can be shown in an archive from 2100 B.C. to have developed conditions of sporadic salinity during the 300 intervening years of cultivation.

2) Crop choice can be influenced by many factors, but the onset of salinization strongly favors the adoption of crops which are more salt-tolerant. Counts of grain impressions in excavated pottery from sites in southern Iraq of about 3500 B.C., made by H. Helbaek, suggest that at that time the proportions of wheat and barley were nearly equal. A little more than 1000 years later, in the time of Entemenak at Girsu, the less salt-tolerant wheat accounted for only one-sixth of the crop. By about 2100 B.C. wheat had slipped still further, and it accounted for less than 2 percent of the crop in the Girsu area. By 1700 B.C., the cultivation of wheat had been abandoned completely in the southern part of the alluvium.

3) Concurrent with the shift to barley cultivation was a serious decline in fertility which for the most part can be attributed to salinization. At about 2400 B.C. in Girsu a number of field records give an average yield of 2537 liters per hectare—highly respectable even by modern United States and Canadian standards. This figure had declined to 1460 liters per hectare by 2100 B.C., and by about 1700 B.C. the recorded yield at nearby Larsa had shrunk to an average of only 897 liters per hectare. The effects of this slow but cumulatively large decline must have been particularly devastating in the cities, where the needs of a considerable superstructure of priests, administrators, merchants, soldiers, and craftsmen had to be met with surpluses from primary agricultural production.

The southern part of the alluvial plain appears never to have recovered fully from the disastrous general decline which accompanied the salinization process. While never completely abandoned afterwards, cultural and political leadership passed permanently out of the region with the rise of Babylon in the 18th century B.C., and many of the great Sumerian cities dwindled to villages or were left in ruins. Probably there is no historical event of this magnitude for which a single explanation is adequate, but that growing soil salinity played an important part in the breakup of Sumerian civilization seems beyond question.

Silt and the Ancient Landscape

Like salt, the sources of the silt of which the alluvium is composed are to be found in the upper reaches of the major rivers and their tributaries. Superficially, the flatness of the alluvial terrain may seem to suggest a relatively old and static formation, one to which significant increments of silt are added only as a result of particularly severe floods. But in fact, sedimentation is a massive, continuing process. Silt deposited in canal beds must be removed in periodic cleanings to adjoining spoil banks, from which it is carried by rain and wind erosion to surrounding fields. Another increment of sediment accompanies the irrigation water into the fields themselves, adding directly to the land surface. In these ways, the available evidence from archeological soundings indicates that an average of perhaps ten meters of silt has been laid down at least near the northern end of the alluvium during the last 5000 years.

Of course, the rate of deposition is not uniform. It is most rapid along the major rivers and canals, and their broad levees slope away to interior drainage basins where accumulated runoff and difficult drainage have led to seriously leached soils and seasonal swamps. However, only the very largest of the present depressions seem to have existed as permanent barriers (while fluctuating in size) to cultivation and settlement for the six millennia since agriculture began in the northern part of the alluvium. More commonly, areas of swamp shifted from time to time. As some were gradually brought under cultivation, others formed behind newly created canal or river levees which interrupted the earlier avenues of drainage.

As the rate of sedimentation is affected by the extent of irrigation, so also were the processes of sedimentation—and their importance as an agricultural problem—closely related to the prevailing patterns of settlement, land-use, and even sociopolitical control. The character of this ecological interaction can be shown most clearly at present from archeological surveys in the lower Diyala basin, although other recent reconnaissance indicates that the same relation-

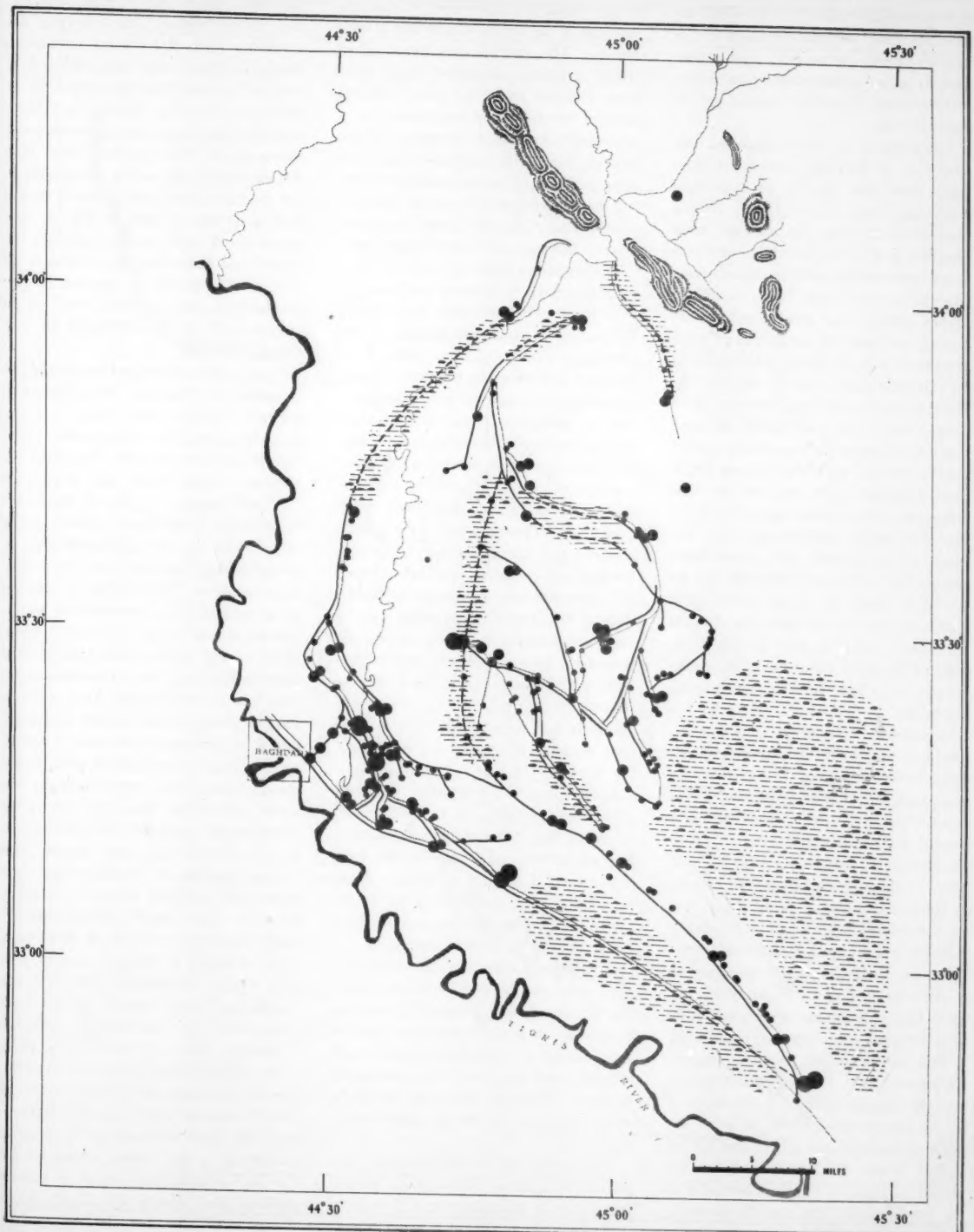

Fig. 1. Early watercourses and settlements in the Diyala region. The system shown in grey was in use during the Early Dynastic period, about 3000–2400 B.C. Sites and watercourses shown in black, slightly displaced so that the earlier pattern will remain visible, were occupied during the Old Babylonian period, about 1800–1700 B.C. In this and subsequent figures, size of circle marking an ancient settlement is roughly proportional to the area of its ruins. Modern river courses are shown in grey.

ships were fairly uniform throughout the northern, or Akkadian, part of the Mesopotamian plain (*2*). To what degree the same patterns occurred in the initially more urbanized (and subsequently more saline) Sumerian region further south, however, cannot yet be demonstrated.

The methods of survey employed here consisted of locating ancient occupational sites with the aid of large-scale maps and aerial photographs, visiting most or all of them—in this case, more than 900 in a 9000-square-kilometer area—systematically in order to make surface collections of selected "type fossils" of broken pottery, and subsequently determining the span of occupation at each settlement with the aid of such historical and archeological crossties as may be found to supplement the individual sherd collections (*3*). It then can be observed that the settlements of a particular period always describe networks of lines which must represent approximately the contemporary watercourses that were necessary for settled agricultural life. For more recent periods, the watercourses serving the settlements often still can be traced in detail as raised levees, spoil banks, or patterns of vegetation disturbance, but, owing in part to the rising level of the plain, all of the older watercourses so far have been located only inferentially.

A number of important and cumulative, but previously little-known, developments emerge from the surveys. By comparing the over-all pattern of settlement of both the early third and early second millennium B.C. (Fig. 1) with the prevailing pattern of about A.D. 500 (Fig. 2) these developments can be seen in sharply contrasting form. They may be summarized conveniently by distinguishing two successive phases of settlement and irrigation, each operating in a different ecological background and each facing problems of sedimentation of a different character and magnitude.

The earlier phase persisted longest. Characterized by a linear pattern of settlements largely confined to the banks of major watercourses, it began with the onset of agricultural life in the Ubaid period (about 4000 B.C.) and was replaced only during the final centuries of the pre-Christian era. In all essentials the same network of watercourses was in use throughout this long time-span, and the absence of settlement along periodically shifting side branches seems to imply an irrigation regime in which the water was not drawn great distances inland from the main watercourses. Under these circumstances, silt accumulation would not have been the serious problem to the agriculturalist that it later became. The short branch canals upon which irrigation depended could have been cleaned easily or even replaced without the necessary intervention of a powerful, centralized authority. Quite possibly most irrigation during this phase depended simply on uncontrolled flooding through breaches cut in the levees of watercourses (like the lower Mississippi River) flowing well above plain level.

It is apparent from the map in Fig. 1 that large parts of the area were unoccupied by settled cultivators even during the periods of maximum population and prosperity that have been selected for illustration therein. An extended, historical study of soil profiles would be necessary to provide explanations for these uninhabited zones, but it is not unreasonable to suppose that some were seasonal swamps and depressions of the kind described above, while others were given over to desert because they were slightly elevated and hence not subject to easy flooding and irrigation. Still others probably were permanent swamps, since it is difficult to account in any other way for the discontinuities in settlement that appear along long stretches of some watercourses. One indication of the ecological shift which took place in succeeding millennia is that permanent swamps today have virtually disappeared from the entire northern half of the alluvium.

Considering the proportion of occupied to unoccupied area, the total population of the Diyala basin apparently was never very large during this long initial phase. Instead, a moderately dense population was confined to small regional enclaves or narrow, isolated strips along the major watercourses; for the rest of the area there can have been only very small numbers of herdsmen, hunters, fishermen, and marginal catch-crop cultivators. It is significant that most of the individual settlements were small villages, and that even the dominant political centers in the area are more aptly described as towns rather than cities (*4*).

An essential feature of the earlier pattern of occupation, although not shown in a summary map like Fig. 1, is its fluctuating character. There is good historical evidence that devastating cycles of abandonment affected the whole alluvium. The wide and simultaneous onset of these cycles soon after relatively peaceful and prosperous times suggests that they proceeded from sociopolitical, rather than natural, causes, but at any rate their effects can be seen clearly in the Diyala region. For example, the numerous Old Babylonian settlements shown in Fig. 1 had been reduced in number by more than 80 percent within 500 years following, leaving only small outposts scattered at wide intervals along watercourses which previously had been thickly settled. An earlier abandonment, not long after the Early Dynastic period that is shown in gray in Fig. 1, was shorter-lived and possibly affected the main towns more than the outlying small villages. Village life in general, it may be observed, remains pretty much of an enigma in the ancient Orient for all "historical" periods.

Under both ancient and modern Mesopotamian conditions, a clear distinction between "canals" and "rivers" is frequently meaningless or impossible. If the former are large and are allowed to run without control they can develop a "natural" regime in spite of their artificial origin. Some river courses, on the other hand, can be maintained only by straightening, desilting, and other artificial measures. Nevertheless, it needs to be stressed that the reconstructed watercourses shown in Fig. 2 followed essentially natural regimes and that at least their origins had little or nothing to do with human intervention. They were, in the first place, already present during the initial occupation of the area by prehistoric village agriculturalists who lacked the numbers and organization to dig them artificially. Secondly, the same watercourses persisted for more than three millennia with little change, even through periods of abandonment when they could not have received the maintenance which canals presuppose. Finally, the whole network of these early rivers describes a "braided stream" pattern which contrasts sharply with the brachiating canal systems of all later times, which are demonstrably artificial.

Specific features of the historic geography of the area are not within the compass of this article, but it should be noted that the ancient topography differed substantially from the modern. Particularly interesting is the former course of the Diyala River, flowing west of its present position and joining the Tigris River (apparently also not in its modern course) through a delta-like series of mouths. A branch that bifurcated from the former Diyala above its "delta" and flowed off for a long distance to the southeast before joining the Tigris has

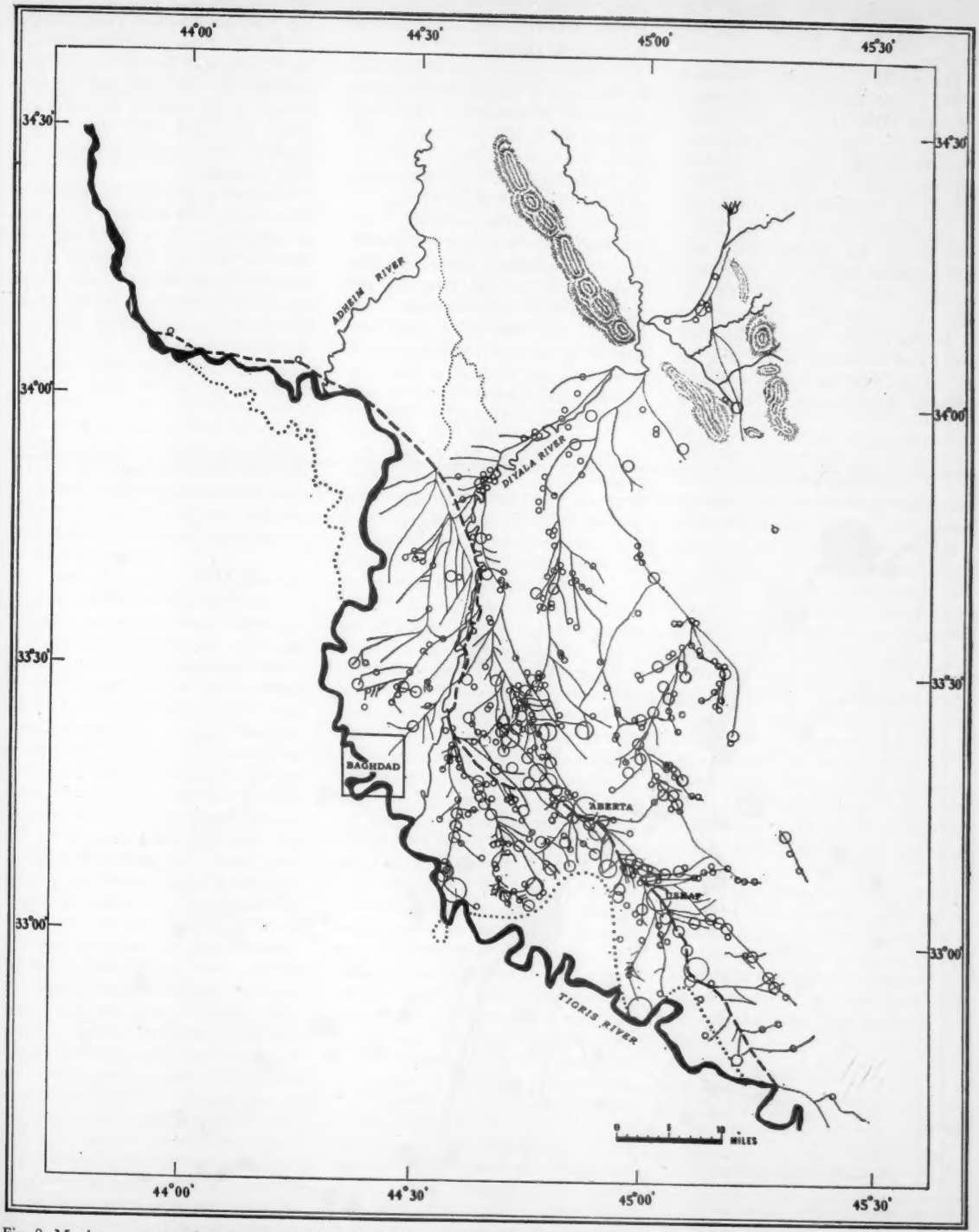

Fig. 2. Maximum extent of settlement and irrigation in the Diyala region. All canals shown by lines with minute serrations were in use during the Sassanian period, A.D. 226–637. However, expansion to the full limits came only with construction of the Nahrwan Canal (shown as a dashed black line) late in the period Settlements shown as black circles are also of Sassanian date. The different course probably followed in places by the Tigris River during the Sassanian period is suggested by black dotted lines.

been identified tentatively as the previously unlocated "River Dabban" that is referred to in ancient cuneiform sources.

The pattern of occupation illustrated in Fig. 2 began to emerge in Achaemenian times (539–331 B.C.), after nearly 1000 years of stagnation and abandonment. Perhaps the pace of reoccupation quickened with the conquest of Mesopotamia by Alexander, but the density of population reached during much older periods was attained again, and then surpassed, only in the subsequent Parthian period (about 150 B.C.–A.D. 226). New settlements large enough to be described as true cities, on the other hand, were introduced to the area for the first time by Alexander's Macedonian followers—demonstrating, if doubt could otherwise exist, that the onset of urbanization depends more on historical and cultural factors than on a simple increase in population density.

A central feature of this second phase of settlement is the far more complete exploitation of available land and water resources for agriculture. There is some evidence that the irrigation capacity of the Diyala River was being utilized fully even before the end of the Parthian period, and yet both the proportion of land that was cultivated and the total population rose substantially further, reaching their maxima in this area, for any period, under the Sassanian dynasty (A.D. 226–637) that followed. A rough estimate of the total agricultural production in the area first becomes possible with records of tax collections under the early Abbasids, perhaps 300 years after the maximum limits of expansion shown in Fig. 2 had been reached. From a further calculation of the potentially cultivable land it can then be shown that (with alternate years in fallow and assuming average yields) virtually the entire cultivable area must have been cropped regularly under both the Sassanians and early Abbasids.

Increased population, the growth of urban centers, and expansion in the area of cultivation to its natural limits were linked in turn to an enlargement of the irrigation system on an unprecedented scale. It was necessary, in the first place, to crisscross formerly unused desert and depression areas with a complex—and entirely artificial—brachiating system of branch canals, which is outlined in Fig.

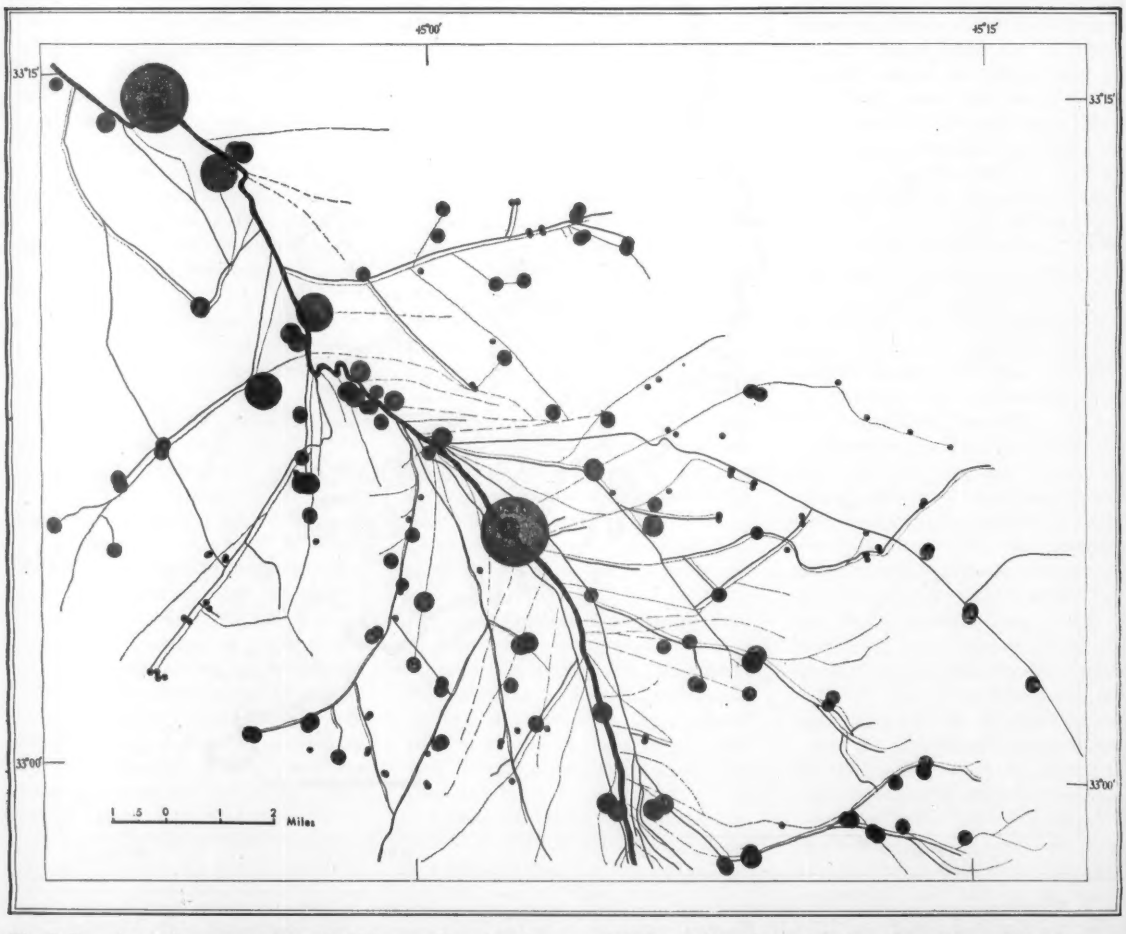

Fig. 3. Branch canal sequence along the Nahrwan. Branches shown as dashed grey lines date to the later Sassanian period (about A.D. 500–637). Settlements shown as grey circles and branch canals shown as continuous grey lines belong to the Early Islamic and Samarran periods, prior to about A.D. 900. Settlements and branch canals shown in black are those in use during the final phase of irrigation in the lower Nahrwan district, about A.D. 1100. The weir excavated by the project was located at the junction of numerous branch canals northwest of the city of Uskaf.

2. Expansion depended also on the construction of a large, supplementary feeder canal from the Tigris which, with technical proficiency that still excites admiration, and without apparent regard for cost, brought the indispensable, additional water through a hard, conglomerate headland, across two rivers, and thence down the wide levee left by the Dabban River of antiquity. Enough survives of the Nahrwan Canal, as the lower part of this gigantic system was called, even to play a key part in modern irrigation planning. Excavations carried out by the Diyala Basin Archeological Project at one of several known weirs along the 300-kilometer course of this canal provided a forceful illustration not only of the scale of the system but also of the attention lavished on such ancillary works as thousands of brick sluice gates along its branches. In short, we are dealing here with a whole new conception of irrigation which undertook boldly to reshape the physical environment at a cost which could be met only with the full resources of a powerful and highly centralized state (*5*).

In spite of its unrivaled engineering competence, there were a number of undesirable consequences of the new irrigation regime. For example, to a far greater degree than had been true earlier, it utilized long branch canals which tended to fill rapidly with silt because of their small-to-moderate slope and cross-sectional area. Only the Nahrwan Canal itself—and that only during the first two centuries or so of its existence—seems to have maintained its bed without frequent and costly cleaning. Silt banks left from Parthian, Sassanian, and Islamic canal cleaning are today a major topographic feature not only in the Diyala region but all over the northern part of the Mesopotamian alluvium; frequently they run for great distances and tower over all but the highest mounds built up by ancient towns and cities. Or again, while massive control installations were essential if such a complex and interdependent system was to operate effectively, they needed periodic reconstruction at great cost (six major phases at the weir excavated by the Diyala Project) and practically continuous maintenance. Moreover, the provision of control works of all sizes acted together with the spreading networks of canal branches and subbranches to reduce or eliminate flood surges which otherwise might have contributed to the desilting process.

None of these consequences, to be sure, vitiated the advantages to be obtained with the new type of irrigation *so long as there remained a strong central authority committed to its maintenance.* But with conditions of social unrest and a preoccupation on the part of the political authorities with military adventures and intrigues, the maintenance of the system could only fall back on local communities ill equipped to handle it. These circumstances prevailed fairly briefly in late Sassanian times, leading to a widespread but temporary abandonment of the area. After an Islamic revival, they occurred again in the 11th and 12th centuries A.D., accompanied by such storm signals of political decay as the calculated breaching of the Nahrwan during a military campaign. On this occasion there was no quick recovery; it still remains for the modern Iraqis to re-establish the prosperity for which the region once was noted.

A closer look at the role of sedimentation along the Nahrwan during the years of political crisis under the later Abbasids is given in Fig. 3. In the first illustrated phase, in late Sassanian times, irrigation water was drawn from the Nahrwan at fairly uniform intervals and applied almost directly to fields adjoining its course. During a second phase, roughly coinciding with the rise of the Abbasid caliphate, irrigation water tended to be drawn off further upstream from the field for which it was destined. This is best exemplified by the increasing importance of the weir as a source for branch canals serving a considerable area. For some distance below the weir the level of the Nahrwan apparently no longer was sufficient to furnish irrigation water above the level of the fields.

By the time of the final phase, soon after A.D. 1100, practically all irrigation in the very large region below the weir had come to depend on branch canals issuing from above it; it is worth noting that two of the largest and most important of these branches simply paralleled the Nahrwan along each bank for more than 20 kilometers. The same unsuccessful struggle to maintain irrigation control is shown by the shrinkage or disappearance of town and city life along the main canal and the depopulation of the initial 5 to 10 kilometers along each major branch issuing from it, while lower-lying communities at the distal ends of the branches continued to flourish.

This cumulative change in the character of the system probably was a consequence of both natural and social factors. On the one hand, silt deposition had raised the level of the fields by almost 1 meter over a 500-year period. Since the natural mechanisms for maintaining equilibrium between the bed of a watercourse and its alluvial levee were largely inoperative in such a complex and carefully controlled system, this rise in land surface may have reduced considerably the level of water available for irrigation purposes. At the same time, inadequate maintenance and subsequent siltation of the Nahrwan's own bed in time sharply reduced its flow and surely also reduced the head of water it could provide to its branches. But whatever the responsible factors were, the result was an especially disastrous one. At a time when the responsibility of the central government for irrigation was eroding away and when population had been reduced substantially by warfare and by prolonged disruption of the water supply, the heavy burden of desilting branch canals remained constant or even increased for the local agriculturalist. If the accumulation of silt was no more than a minor problem at the beginning of irrigation in the Diyala basin 5000 years earlier, by the late Abbasid period it had become perhaps the greatest single obstacle that a quite different irrigation regime had to deal with.

With the converging effects of mounting maintenance requirements on the one hand, and declining capacity for more than rudimentary maintenance tasks on the other, the virtual desertion of the lower Diyala area that followed assumes in retrospect a kind of historical inevitability. By the middle of the 12th century most of the Nahrwan region already was abandoned. Only a trickle of water passed down the upper section of the main canal to supply a few dying towns in the now hostile desert. Invading Mongol horsemen under Hulagu Khan, who first must have surveyed this devastated scene a century later, have been unjustly blamed for causing it ever since.

References and Notes

1. The Diyala Basin Archeological Project was conducted jointly by the Oriental Institute of the University of Chicago and the Iraq Directorate General of Antiquities, on a grant from the First Technical Section of the Development Board. It was directed by one of us (T. J.), with the other (R. M. A.) and Sayyid Fuad Safar, of the Directorate General of Antiquities, as associate directors. Excavations were under the supervision of Sayyid Mohammed Ali Mustafa, also of the Directorate General of Antiquities. Field studies of paleobotanical remains were undertaken in association with the project by Dr. Hans Helbaek, of the National Museum, Copenhagen, Denmark. Intensive study of the cuneiform and Arabic textual sources on agriculture was made possible through the collaboration of scholars of many countries. Especial thanks for assist-

ance to the field program in Iraq, and for advice in the interpretation of its results, are due to Mr. K. F. Vernon, H. E. Dr. Naji al-Asil, Dr. J. C. Russel, and Sayyid Adnan Hardan.

2. R. M. Adams, *Sumer*, in press.
3. A preliminary application of this approximate methodology to conditions prevailing in Iraq was introduced by one of us (T. J.) in the Diyala basin in 1936–37, and the results of that earlier survey have been incorporated in the present study. Fortunately for the archeologist, there is sufficient disturbance from routine community activities (for example, foundation, well, and grave digging, and mud-brick manufacture, and so forth) for some traces of even the earliest of a long sequence of occupational periods to be detected on a mound's surface.
4. Partial town plans for the political capital of the region at Tel Asmar (ancient Eshnunna) and for two other slightly smaller centers are available from extensive Oriental Institute excavations carried out in the Diyala region between 1930 and 1937. See P. Delougaz, *The Temple Oval at Khafajah* [Oriental Inst. Publ. 53 (Univ. of Chicago Press, Chicago, 1940)]; P. Delougaz and S. Lloyd, *Pre-Sargonid Temples in the Diyala Region* [Oriental Inst. Publ. 58 (Univ. of Chicago Press, Chicago, 1942)]; and H. Frankfort, *Stratified Cylinder Seals from the Diyala Region* [Oriental Inst. Publ. 72 (Univ. of Chicago Press, Chicago, 1955)], plates 93–96. For recent general overviews of the history and culture of the earlier periods, see A. Falkenstein "La cité-temple Sumérienne" [*Cahiers d'Histoire Mondiale* 1 (1954)] and T. Jacobsen, "Early political developments in Mesopotamia" [*Z. für Assyriologie* (N.F.) 18 (1957)].
5. General accounts of political, social, and cultural conditions in Mesopotamia during the Persian dynasties and under the Caliphate are to be found in R. Ghirshman, *Iran* (Pelican, Harmondsworth, Middlesex, England, 1954) and P. K. Hitti, *History of the Arabs* (Macmillan, London, ed. 6, 1956).

Mr. Keynes and the "Day of Judgment"

How useful is the great economist's gloomy model in the light of today's thought and experience?

David McCord Wright

If consistency is the bane of little minds, Lord Keynes had certainly a great one. No one who studies the work of John Maynard Keynes can fail to be impressed by the frequent brilliance of his insights and the usefulness of many of his tools of analysis. But he lacked that sober quality which causes a man to sit down and carefully consider the consistency of his various successive theories and pronouncements. Keynes at various times approved, in writing, the essentials of a number of different restatements of his system, including one written by me (*1*). But when we compare the different models, thus approved, we find them to vary widely among themselves. The trouble lies in the fact that his basic model was founded on extremely narrow assumptions, and that he did not bother always to make clear to what extent he felt these assumptions applicable at a given time, and how much, in any case, he was willing to relax them (*2*).

Keynes' successors and disciples therefore differ widely among themselves in their interpretations. Also, it is difficult to separate one part of Keynes' analysis from the rest. However, since selection is necessary, I have picked out for explanation and criticism that interpretation of Keynes which has, unfortunately, become most widely connected with his name.

Few aspects of Keynes' system influence modern thought more than what one of his early reviewers has called "Mr. Keynes' vision of the day of judgment"—that oft expected crisis when unregulated capitalist expansion shall be brought to an end by overinvestment or underconsumption. So deeply has this picture affected the minds of a whole generation of economists that whenever—as in the last few months—the employment index falters, it requires unusual courage and balance for an economist to resist the cry that here at last is the predicted collapse.

Yet it is not easy to dig out of Keynes' *General Theory of Employment, Interest and Money* the reasoning which underlies his frequently gloomy views (*3*). The book is an unusually difficult and disorderly one. In essence it consists of three separate and distinct threads of analysis which Keynes himself and many of his disciples often confuse: (i) a very precise mathematical model based upon factual assumptions which are frequently inapplicable, (ii) a set of tautological definitions which *sound* as if they conveyed meaning but which, as one acute critic puts it, "achieve a magnificent generality by being about nothing at all," and (iii) a number of practical policy suggestions, some of which are extremely valuable and some quite the reverse. Space is lacking here to review the complicated but arid field of Keynesian terminology. What I shall do in this article is, first, to outline Keynes' basic mathematical model on which his "day of judgment" ideas are based, second, to show how limited it is, and third, to show, from a study of these limitations, wherein scientific truth requires that his conclusions and many of his policy suggestions must be seriously modified.

How the Basic Model Works

Characteristically, Keynes deferred a statement of the basic assumptions of his fundamental model until the *eighteenth* chapter of his book, where they are often overlooked. Yet everything in his model depends upon these assumptions, and I am sure that if their limited nature were more widely recognized, Keynes' conclusion would have far less prestige. The crucial passage runs as follows:

"We take as *given* the existing skill and quantity of available labour, the existing quality and quantity of available equipment, the existing technique, the degree of competition, the tastes and habits of the consumer . . . the social structure including the forces . . . which determine the distribution of the national income. This does not mean that we assume these factors to be constant; but merely that, *in this place and context, we are not considering or taking into account* the effects and consequences of changes in them" (italics supplied) (*3*).

This passage (some of the more tech-

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nical sentences are omitted) assumes in effect that (i) there is no technical change or invention, (ii) there is no change in taste, (iii) there is no change in population or resources, and (iv) there are no changes in the preferences of the population between work and goods, on the one hand, and leisure, on the other. These assumptions, it will be seen, in effect "freeze" the system, and practically every dynamic element of capitalist civilization is removed. Of course, as he explains, Keynes did not mean that these forces were always lacking in reality. But what he did mean, and the point cannot be too often stressed, is that *in the basic model* on which his system rests, virtually *all the dynamic social forces are omitted.*

Let us, however, proceed. By a combination of intuition and mathematics, most, but by no means all, economists assume that *granted* such a frozen system, three absolutely vital conclusions can be drawn. These are: (i) Investment depends upon consumption. Nobody will build a new factory unless demand for its product is increasing. (ii) There is a fixed mechanical ratio, called by R. F. Harrod of Oxford "the relation," between the flow of consumer goods and the amount of "capital" or equipment needed to produce them. (iii) Finally, and most important, it is possible under these fixed conditions to assume an ultimate condition of "full investment" or saturation. At this saturation point, a society has (i) accumulated as much equipment as it can usefully employ and (ii) is producing a maximum output of consumer goods. This does *not* mean that everybody has all he wants. It only means that given the existing state of knowledge and resources, and the given preferences between leisure and goods, expansion has reached a limit. People *could* make and enjoy more goods, but they would rather take a vacation.

Let us now proceed to the working of Keynes' basic model, presenting it, however, in simple language, and not employing his special terms. An economic system, we may suppose, is beginning to expand from a state of unemployment. Or else a *given* set of new techniques is being introduced in some undeveloped country. What will happen? Keynes has two models. The first depends upon what he calls the "normal law of consumer's behavior." This means that, as output rises, consumption also rises, but not as fast. People get richer but do not increase their consumption expenditure as fast as their income is rising. Such a difference in production and consumption trends spells, he thought, inevitable crisis. For consider: *under our assumptions,* investment depends on consumption. Factories are not built unless their products are being demanded. Now, if more and more factories (proportionately) are being built, and less and less increase (proportionately) in consumption is taking place, there soon must come a point beyond which more equipment cannot profitably be built. Yet people are not spending their full income. The unspent money piles up in the banks, which cannot find solvent borrowers for it. Men are unemployed. There is a crash.

Keynes' second version is more sudden. People, we may suppose, keep consuming the additional output of consumer goods right along. But finally the "condition of full investment" or saturation point is reached. There is no need for further construction of houses, factories, and equipment. Only replacement is needed. But society has gotten itself into the habit of saving more money than is needed for mere replacement. This habit, it is said, will persist though no longer needed. Again money will go unspent. Funds will pile up. There will again, but more suddenly, be a crash. The capitalist urge to accumulate survives its usefulness and produces unemployment. This is the Keynesian vision of the day of judgment (*4*).

The Heretics versus the Orthodox Economists

Curiously enough, once we scrape all the verbiage off Keynes' model, as has been done in the preceding section, and omit his special analytical constructs, it will be seen that the model is not particularly original. Much the same line of reasoning can be found in the work of the "heretics"—Marx and Veblen, for example. Still more remarkable, many of the same assumptions, but with quite different conclusions, appear in the work of the "orthodox" economists, notably David Ricardo (*circa* 1810) and John Stuart Mill (circa 1848) (*5*). Ricardo and Mill both often used models that were just as "frozen." They both assumed a "saturation" point was possible. They both often felt that investment depended on consumption. Yet they came out at quite a different place. How was this possible?

The difference lies in the fact that Ricardo and Mill switch the argument over from how much investment is needed to why people save. They considered motives, and by considering motives got very different consequences. "Why," Ricardo asked, "did a man build a new factory?" "Why, because he expected to make a profit from it," was the answer. "Why," he asked further, "did a man save money?" "Well, because he wanted to get interest on his savings" was Ricardo's answer. "Suppose I expect to make a considerable profit from a new factory," said Ricardo, "but I don't have enough money to build it. What will I do?" The answer seemed obvious: "Use part of your expected profit to pay interest on a loan from someone else."

From these ideas it was possible to deduce a complete theory of adjustment. If, as at the beginning of an expansion, there are many prospects of profit, profit expectations will be high. Many people will be wanting to borrow money to build new factories to take advantage of them. Competing against each other for a limited supply of savings, they will force up the price of loans—the rate of interest. But on the other hand, thought Ricardo, if interest rose, more people would want to save. Thus his argument was as follows: A need for new construction will produce high profit prospects. High profit prospects will increase borrowing for investment and force up the rate of interest. But higher rates of interest will increase saving. This will make it possible to expand even faster.

Still more important, the argument can be put into reverse. As society approached a saturation point, profit prospects, Ricardo thought, would fall. Fewer people would want to borrow. In consequence, the rate of interest would fall. But if interest rates fell, fewer people would want to save. Thus, as the need for saving declined, the urge to save would drop with it. People saved for the same reason, say, that they grew potatoes. If the price of potatoes is high, more potatoes will tend to be grown; if lower, fewer. So it was also, Ricardo thought, with saving and the rate of interest. While at one point there might be high interest and high saving and investment, and at another low interest and low saving and investment, there would, it is true, be adjustments back and forth, but never serious unemployment. Ricardo's theory was followed by Mill. And with much refinement and elaboration this remained the accepted, orthodox theory of interest, saving, and employment until the publication of Keynes' *General Theory* in 1936.

Wherein, again scraping off special

verbiage, does Keynes spoil this pretty picture? He does it in two ways. First of all, Keynes points out, people do not save money merely to get interest. In the short run they may have quite other motives—to provide for old age, for instance. Thus a drop in the rate of interest, because of a drop in expected profit, need not stop people from trying to save, or start them spending. On the contrary, they may, for quite a while, not react at all. But the situation is even worse. For, said Keynes, people do not merely save money to lend at interest. They can also merely *hold* money, or accumulate stocks of it. And a man may be unwilling to let go his stock of money unless he is paid for doing so. Thus Keynes said that the rate of interest was the price "paid for parting with liquidity." Men want at the very least to be sure of getting their principal back. And when there are many risks they must be paid a premium to compensate for bearing them (*6*).

An elaborate and complicated analysis has been built around these questions. All that we need to remember here, however, is that the rate of interest is determined not merely by the profit prospects of the borrower interacting with the desire of people to save, but also by the "liquidity preference" or caution of lenders. The repercussions upon the optimistic interest and employment theories of Ricardo and Mill are most severe. For not only does consumption not necessarily rise as the rate of interest falls, but also, even though society is thought to be experiencing a glut and hence profit prospects are low, the rate of interest may not fall at all, since "liquidity preference" may have risen in an offsetting manner. There are thus not two but three possibilities: continual smooth growth, Ricardian adjustment to saturation, and unemployment crisis.

It is from this analysis that most pessimistic "day of judgment" theories take their beginning. Forgetting the limited nature of the basic model upon which their ideas depend, many modern economists assume: (i) investment depends on consumption; (ii) a glut of equipment or "condition of full investment" is possible; (iii) when profit prospects rise or fall the rate of interest need not move with them because liquidity preference may be shifting independently; (iv) consumption does not necessarily shift with changes in the rate of interest. Add all these assumptions together and the possibility of devastating and even permanent crisis arises. But a scientific economist cannot stop at this point, for we have not yet considered the validity of the basic assumptions. Our job next, therefore, is to carry the argument back to its base and to show wherein its ultimate foundations are inadequate.

Validity of the Underlying Assumptions

Does investment necessarily depend upon consumption? I mean, is it true that investment in the real world will be made only on a rising demand? To show how mistaken the idea is, when stated as a universal principle, let us ask ourselves under what circumstances a brewer, say, might build a new brewery even though the volume of total beer sales or the price of beer, or both, were falling.

There are three cases: the better beer, the cheaper beer, and what I have called the "bullheaded brewer" (*7*). If a man invents a new kind of beer which he thinks is going to attract sales from other brands, it may pay him to build a new brewery even though general beer sales are falling. And the shot in the arm given by his new construction *could* raise not only general beer sales but employment in other lines as well. Next, if a man gets hold of a new and much cheaper method of brewing, it may pay to build the new brewery even though beer sales and prices are falling. For though prices are declining, say 2 percent, if costs are reduced 20 percent, a substantial profit margin remains. Finally, a business man may simply feel that he is smarter than the market and he (the "bullheaded brewer") may go ahead and build though things are still depressed. And it is again undeniable that his courage and the stimulus of the construction he is carrying through may start the economy once more expanding.

One final case must be mentioned in which investment does not depend upon present consumption. That is the case of investment made on a basis of long-run trends, say of population growth, and not on the basis of present demand. Among such projects are tunnels, highways, subways, and railroads. Such projects are actually stimulated by depression. For in depression, interest rates are often low, and costs low, and since it is the long-run trend that is the motivating force, and not present consumption, the immediate drop in demand will not be important. Thus, as one well-known writer has put it, "the system can be dragged out of depression by that section of construction which belongs to the future."

One does not get the full impact of what we have been saying until one realizes that the economic system is not just a two-story affair of machines and consumer goods. Rather, it is set up in many layers, like a cake. There are the machines that make consumer goods, and the machines that make machines, to say nothing of the machines that make machines that make machines, and so on ad infinitum. The problem is further complicated by many loops and whirlpools in the input-output flow. Now *anywhere,* and at *any time* or point in the flow, the cheaper and the "better" product may be being introduced, or some businessman may think he can outguess the market, or investment of a very long-term nature may be stimulated. Thus, while department store sales, let us say, have dropped 5 percent, this does not necessarily mean a drop in investment. New inventions may at the very same time be *boosting* investment demand by 10 percent. The economic system in a capitalist economy (and in most socialist ones) is not, practically speaking, a single, tidily articulated mechanical flow. All sorts of spontaneously occurring changes up and down the stages of production may completely nullify the effects of either a drop or an increase in consumer purchases.

Businessmen, who, to succeed, have to be good practical economists, usually know the leeway there is in the system for unexpected change. Consequently, a businessman is much more interested in his expectations regarding his immediate market than in fluctuations in demand for more remote industries. Consumption is therefore only one factor in the situation, and not necessarily a controlling one. Furthermore, even consumption does not behave with the mechanical simplicity postulated by Keynes. Many consumers have cash or can obtain credit. So far from always lagging during expansion, consumption can sometimes rise faster than general expansion. This would reduce inventories and stimulate the economy still further. The statistical record is clear that, in the real world, we must be prepared for highly erratic, unpredictable shifts in the general level of consumption (*8*).

So much for the vagueness of the relation between consumption and investment. What about the point of general saturation, or "full investment"? Here, too, precision vanishes as we approach reality. For, again, the statistical record

is clear that in the real world human wants do not stay put. As output rises wants, on average, tend to rise with it. Luxuries become necessities and erstwhile necessities drop out altogether. Even a monastery of contemplative monks can generally use a larger library! And Lewis Mumford lists among the *necessities* of life "Poetry, drama, and idle play," all of which, if one knows anything of comparative civilizations, can absorb immense amounts of capital.

The problem, then, is not so much a lack of general desire, as an inability, in the short run, of the directors of production perfectly to foresee the shifts of consumers' desires and to adjust the pattern of production to them. Were businessmen or socialist bureaucrats equipped with x-ray eyes which would enable them to read off the wants of the consumer six months *before he knew he had them,* and able to make quick and perfectly accurate adjustment to these wants, there would never be a glut. But the expanding society (any expanding society) is always advancing into what I have called a "fog of futurity." There are bound to be mistakes. Such advantages as socialism possesses in the matter of stability lie largely in the ability of socialist bureaucrats to refuse to gratify the known wants of consumers and to slow down the whole process of growth-change to a slow enough pace (frequently very slow) for them to handle (*9*).

The problem in fact is best visualized in terms of *flows of demand* of various sorts, plus *rates of change* of those flows. We can think of a certain proportion of the output of society being used to produce, say, wheat, so much used to produce cloth, and so forth. We can think also of such and so many men being employed in technical change, so many in simple expansion, so many in replacement. The essence of the problem is that all these rates of flow are, in an expanding society, constantly shifting. We get full employment when all of these shifting relationships add up to full employment. We get pressure toward inflation when they exceed that amount, and deflation when they fall below it. But the movements of these flows do not conform to the simple rules of the Keynesian model. In practical experience, the Keynesian forecasters have quite a poor record (*10*). On a purely pragmatic basis, therefore, we have excellent grounds for questioning the adequacy of the Keynesian models.

What determines the rates of change? Here the mathematical economist must call in the sociologist and many other social scientists, besides the accountant. Advertising, the anthropological culture concepts of a people, even their religion and politics, will deeply affect the rate and direction of their shifting patterns of wants.

Yet, confining the question to the purely economic calculus, I have already demonstrated enough in this article to call in question much of Keynesian thought. While Keynes himself knew better (and often remembered to say so), the general trend of his argument, and the normal reaction of most of his disciples is: In the face of a drop in output and employment, just stimulate demand (*11*). Put in more money, it will be said, say by increasing the national debt through bank credit, or discourage saving by "soaking the rich."

Now so far as I am concerned, it cannot be denied that circumstances could arise in which it would be desirable to inject more money, rather than risk a general collapse. But I hold that Keynes' one-eyed concentration upon consumption, and the "soak the rich" policies often deduced from it, constitute very often an important barrier to real understanding of the problem. In other words, his remedies are sometimes not merely useless but actually harmful. For they keep us from thinking about the main problem.

A Practical Example

A practical example will be helpful, and it is ironic that the one most easily cited is the crisis from which Keynes wrote his book: the English unemployment crisis of the 1920's. There, the real trouble lay in a lag in the relative technical productivity of British industry which placed British goods at a disadvantage relative to those of Britain's competitors in export trade. Because the United Kingdom's industry was lagging technologically, her prices were high and sales low. Because her prices were high, investment prospects were unprofitable. Because investment prospects were unprofitable there was unemployment. The real need was thus for modernization. Keynes, however, picking up the argument in the middle, talked about increasing consumption, or tinkering with exchange rates. These remedies were in the nature of treating a fever with aspirin. They could at best be short run.

But not only in the case of countries like the United Kingdom which depend on export trade, is Keynes often misleading, but in general analysis as well. The real motive power of industry as it advances into the future is not just consumption, but what might be called the perspective of profit, seen over several years, between expected price trends and expected cost trends (*12*). It is true that business does not take advantage of every immediate profit. It takes a long view, often forgoing short-run advantage for the surer gains of prolonged "good will." It is true that some investment is made in which profit considerations have no part. But there is a critical margin in which they are enormously relevant.

Now the real cause of a depression can sometimes be not a lack of consumption but a maladjustment of cost and prices. Wages can be rising faster than productivity, and hence the prospect of profit is reduced. Or taxes may be so heavy as to have the same effect and leave little incentive. Under these circumstances, just putting in more money will not help the basic problem. And there is one further problem that can never be forgotten. The extra money put in during depression to stimulate the economy may not *at first* cause inflation, but that money will not just die. As after World War II in the United States, the piled up accumulations of years of deficits may later on suddenly explode, plunging the nation into severe inflation.

References and Notes

1. A word is in order concerning my relationship to Keynes. I had published an article in the *Economic Journal,* of which he was editor, and sent him a copy of my first book, *The Creation of Purchasing Power* (Harvard Univ. Press, Cambridge, Mass., 1942). Shortly thereafter, I received a letter from Keynes commenting upon it at length. This began a correspondence which lasted down to his death; indeed, the last letter which I received from him reached me after I had read of his death in the newspapers. Thus, although I never met him personally, I do feel that I have some knowledge of one side, at least, of his outlook. My interpretation of Keynes' system, which Keynes himself approved in general and in writing, is given in my article "The future of Keynesian economics," *Am. Econ. Rev.* (June 1945). A good, brief explanation of the more mechanical approach to Keynes' work will be found in Joan Robinson, *Introduction to the Theory of Employment* (Macmillan, New York, 1937). Extensive bibliography and biographical data, as well as technical essays, are to be found in S. E. Harris, *The New Economics* (Knopf, New York, 1947). See also R. F. Harrod, *The Life of John Maynard Keynes* (Macmillan, New York, 1951). My reservations concerning the general line of interpretation followed in these titles will be found in my review article "The life of John Maynard Keynes," *J. Public Law* (Emory University, Ga.) (Spring, 1952).
2. How far Keynes himself was from a merely mechanical application of his model will be seen by the fact that he wrote me that he agreed with me that we would not be likely to have unemployment and saturation after World War II "for some time to come," but rather inflation. This was at the time when most of his American disciples were predict-

ing an unemployment crisis practically immediately upon the conclusion of peace.

3. J. M. Keynes, *The General Theory of Employment, Interest and Money* (Harcourt Brace, New York, 1936).
4. There is a special possible exception to this theory of collapse. It could be that about the time further *net* accumulation ceased to be necessary, the replacement demand to maintain the (hitherto) growing stock of capital would increase. Thus the gross demand for newly produced equipment and capital goods would not drop, though demand for a *net* increment had fallen to zero.
5. See J. S. Mill, *Principles of Political Economy*, ed. 6, book IV, chap. IV, sect. 4 "Such a country . . . is habitually within as it were a hand's breadth of the minimum and the country therefore on the verge of the stationary state." Ricardo's views, which I here paraphrase and summarize, will be found scattered through his various books, pamphlets, letters and notes, all set forth in *The Works and Correspondence of David Ricardo* (10 vol.) edited by Piero Sraffa with the assistance of M. H. Dobb (Cambridge Univ. Press, London, 1951). A typical quotation from Ricardo's works (vol. 2, p. 438) is as follows: "no mistake can be greater than to suppose any evils whatever can result from an accumulation of capital. The sole consequence might be an indisposition to accumulate further from the fall of profits."
6. The special risk, which Keynes particularly elaborated, is that of a capital loss if prosperity returns and the rate of interest *rises*. A perpetual income of a dollar a year at 2 percent has a capital value of $50. At 4 percent its capital value is only $25. Because of this special danger of capital loss, men may hold money rather than invest it at low interest rates. Keynes called this the "speculative motive" of "liquidity preference." The subject has become much tangled in elaborate verbiage. Increasingly, however, it is being realized that Keynes' theory can be treated as supplementary to, rather than contradictory of, "orthodox" theory. See my "The future of Keynesian economics" (*1*) for a technical discussion.
7. An elaborate explanation of this problem, in simple language, will be found in D. M. Wright, *A Key to Modern Economics* (Macmillan, New York, 1954), chap. IX, sect. 2. The reader is referred to this book for general elaboration of the points set forth in this article.
8. I have given an elaborate theoretical analysis of the interrelations (and lack of interrelation) between markets in "What *is* the economic system?" *Quart. J. Econ.* (May 1958). The egregious failure of most Keynesian forecasts after World War II was very largely due to an unexpected upward jump of the consumption level. Similarly, in 1953 and again in 1958 the Keynesian models of mechanical interrelationships between investment and consumption did not work out. Of course this does not prove that his model cannot sometimes be useful. It only proves that it is not universal or reliable.
9. For an analysis of some of these problems of speed which the socialist planner encounters, see D. M. Wright, *The Economics of Disturbance* (Macmillan, New York, 1947), chapters III and VI. This book was written during the war and its analysis was worked out entirely from *ad hoc* logic, given a few premises which I believed to be true. It has, therefore, been extremely interesting to watch the subsequent accumulation of an immense mass of data illustrating the practical occurrence of the dilemmas therein predicted.
10. Examples of failure of the postulated Keynesian relationships are mentioned in (*8*).
11. Keynes' views on wages have been particularly often misunderstood and misstated. How many people, for example, remember that Keynes wrote the following: "When we enter on a period of weakening effective demand a sudden large reduction of money wages to a point so low that no one believes in its indefinite continuance would be the event most favorable to a strengthening of effective demand" (*3*, p. 265). Or, "a general reduction [of money wages] may also produce an optimistic tone in the minds of entrepreneurs, which may break through a vicious circle of unduly pessimistic estimates . . . and set things moving again on a more normal basis of expectation" (*3*, p. 264). Finally, in his *Essays in Persuasion* [(Harcourt Brace, New York, 1932), p. 341] he refers to the labor unions as "once the oppressed, now the tyrants, whose selfish and sectional pretensions need to be bravely opposed." The truth is that, scientifically, Keynes was a highly schizoid character.
12. Concerning the "perspective" of profit, see D. M. Wright, "What *is* the economic system?" (*8*).

Science Teaching Improvement Program

Changes in interest in science education point to gains, if regional effort can be increased.

John R. Mayor

In the 3 years since a grant from the Carnegie Corporation enabled the American Association for the Advancement of Science to begin its Science Teaching Improvement Program (STIP), a very substantial change has developed in the United States in the interest in and attitudes toward the teaching of science and the education of science teachers. Most of the change has been in attitudes and interest, for a 3-year span is not long enough for alteration in the materials actually taught or in the ways in which teachers are prepared for their responsibilities. But the changes in interest and attitude are forerunners of changes in practice, and already it is evident that major changes in practice are coming. The great expansion in number of summer and academic-year institutes for teachers and the several well organized efforts to prepare up-to-date course material of high quality in physics and mathematics are outstanding examples. Further evidence is provided by the increasing number of colleges and universities that are offering special science and mathematics courses for teachers and prospective teachers, the number of states and universities in which special committees of scientists and educators have been established to work together on problems of teacher preparation, the increased number of studies being conducted of the science curriculum and of science teaching materials, and the greatly increased willingness of scientists to devote time and thought to the problems of education below the collegiate level.

There is no way of knowing—and we have made no attempt to find out—how much of the credit for these changes can properly be given to the AAAS and its Science Teaching Improvement Program. The STIP staff and publications, and the annual meeting and committee resources of the AAAS have been wholly or in part directed toward these ends. Part of the change can no doubt be credited to the Association's activities.

Instead of considering the unanswerable questions of proportion of credit, it will be more useful to describe the work done.

Use of Science Counselors

Many persons teaching high-school science and mathematics courses are not adequately educated in the fields of knowledge they teach. As one means of improving the quality of teaching in science and mathematics, arrangements were made with the state universities of Oregon, Nebraska, and Texas, and Pennsylvania State University, to employ two

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experienced and highly qualified teachers to serve as counselors to less experienced colleagues in the regions surrounding those universities. In each state a science counselor and a mathematics counselor were employed. In each state the program was developed with full cooperation from the state department of education, the university science, mathematics, and education departments, and the high schools concerned. The counselors were employed as members of the university staff and served, essentially, in an "extension" capacity. Each visited teachers within a prescribed geographic region (usually about 100 teachers per counselor) to help those teachers with problems of subject matter, teaching, use of equipment, examinations, science fairs or other such activities, and use of local educational resources outside the formal school system. Emphasis was on subject matter, rather than pedagogy. The cost was largely borne by grants made by the Association, but in no case did the grant cover all of the costs; the university had to be sufficiently interested in the program to share part of the expense.

An evaluation of this program through questionnaires and interviews with teachers, university faculty members, superintendents and principals, and others involved has been carried out by John W. Gustad of the University of Maryland and will be reported in full at an early date. Such informal evidence as comes from letters and reports indicates that the program was effective, successful, and —after an initial period of uncertainty and in a few cases some suspicion—well liked by all of the groups involved.

More tangibly, the University of Texas is continuing the program, with financial support from the school districts visited by the counselors. In fact, the program has been so well received that additional schools have wanted to be included. In the other three states the program has been dropped for the year 1958–59 because financial arrangements for its continuation had not been worked out. But in all three places, efforts are being made to resume the use of science and mathematics counselors in the fall of 1959 with financial support from the university budget.

Broader recognition of the usefulness of science counselors was evident in the inclusion of provisions for such counselors in the education bills introduced into Congress in 1958 by the Administration and by Senator Hill and Representative Elliott. The provisions of the Hill-Elliott bill were quite directly based on reports of the Association's counselor program. In the National Defense Education Act of 1958, federal grants to the states for the improvement of science, mathematics, and foreign language teaching are made contingent upon the expansion or improvement of supervisory services similar to those performed by the counselors in the Association's program. It is possible that in another year science counselors may be active in all 49 states.

Education of Science Teachers

The widespread concern with the problem of improving the education of science and mathematics teachers has been shared by the Association, and several efforts have been made to improve teacher education.

Joint Commission on the Education of Teachers of Science and Mathematics. In the fall of 1955 the AAAS, the National Science Foundation, the U.S. Office of Education, and the American Association of Colleges for Teacher Education held a small conference on the problem of securing greater cooperation between scientists and educationists in the education of science teachers. As a means of continuing the purpose of this conference, early in 1956 the AAAS and the American Association of Colleges for Teacher Education formed a Joint Commission on the Education of Teachers of Science and Mathematics. The Joint Commission consists of four representatives of each of the parent organizations plus one representative each of the National Science Foundation, the U.S. Office of Education, the National Science Teachers Association, the National Council of Teachers of Mathematics, the American Council of Learned Societies, and the Association of American Colleges.

In the course of a series of meetings, the Joint Commission developed a program of experimental studies on teacher education, but it was never possible to come to full agreement on which such studies were of greatest importance and how they might best be handled. Out of this inability came another result of potentially greater usefulness: an examination of the basic question of what the science curriculum in elementary and secondary grades should be. A statement on elementary and secondary school science education has been prepared and has provided the basis for a number of recommendations concerning both preservice and in-service education of science teachers. This statement has been agreed upon by the members of the Joint Commission, has survived the criticism and gained the endorsement of several conferences of scientists, educationists, and school teachers and administrators, and is now being prepared for publication.

Conferences for Staff Members of Teachers Colleges. A considerable fraction of the nation's school teachers are trained in state teachers colleges. Two conferences were held for staff members of such institutions, one in Chicago in 1957 for representatives of midwestern institutions, and one in Washington, D.C., in 1958 for representatives of mideastern states. These were two-day conferences, involving both scientists and educationists, in which emphasis was upon subject matter education.

In-service Training of Teachers in the Washington, D.C., Area. The AAAS cooperated closely with the National Academy of Sciences–National Research Council in developing a local program of teacher education. It involved cooperation among the several school districts in and surrounding Washington, D.C., the several universities in the area, local parent groups, and local industrial and business representatives. The purpose was to try to develop a locally sponsored and financed program, without outside financial aid (except for the very substantial amount of time that went into planning and organization on the part of AAAS and NAS–NRC staff members). Arrangements were made for the universities to offer special courses during the summer months, and for the local school systems (or other local sources of funds) to provide stipends for the teachers who enroll in these courses. The program is continuing.

Experimental Course for Mathematics Teachers. With the cooperation of the National Academy of Sciences–National Research Council, the department of mathematics of the University of Maryland, and the Walter Reed Army Medical Center, an experimental course in the concepts of the calculus for high-school teachers was given over closed-circuit color television during the 1957–58 school year. The NAS–NRC is hoping to make kinescopes available for use in several other centers during the academic year 1958–59, and the AAAS will be involved in the planning for this use of the kinescopes.

Correspondence Courses for Teachers. STIP has worked with a committee of the National University Extension Asso-

ciation in preparing a summary of extension courses that are now available for in-service teachers. The list will be published and the committee intends to encourage the development of additional courses during this coming year.

Certification of Teachers

The bases on which persons are certified as qualified to teach, or to teach specified subjects, is a topic of wide current concern and discussion. One of the major points involved is the amount and nature of subject matter preparation to be required. STIP has worked closely with the National Commission on Teacher Education and Professional Standards and has selected scientists to work with state and regional teacher education and professional standards organizations during 1956–57 and 1957–58. These meetings culminated in a national conference held in Bowling Green, Ohio, on 24 to 28 June. In attendance were some 250 scientists and representatives of other academic disciplines who had been invited by the AAAS, the National Academy of Sciences–National Research Council, and the American Council of Learned Societies. A special grant of the Carnegie Corporation to the National Commission paid some of the unusual costs of this conference. The recency of the meeting means that the only available evidence concerning its effect is of the "testimonial" variety, but that evidence indicates a highly successful meeting that will increase substantially the extent to which subject-matter specialists and educationists work jointly on matters of teacher preparation and certification, and that will increase substantially the number of subject-matter specialists who are actively involved in decisions concerning teacher certification.

Certification requirements vary substantially from state to state. Representatives of the Science Teaching Improvement Program have conferred with officers of the National Association of State Directors of Teacher Education and Certification in the planning of a national study of teacher certification practices, a study that will lead, it is hoped, to agreement on basic principles and reciprocity patterns among the states. The National Association of State Directors of Teacher Education and Certification has asked for a greater amount of continuing assistance as the study is carried out.

Cooperation between Scientists and Educationists

One of the major objectives of the Science Teaching Improvement Program has been to close the gap between scientists and educationists and to get the two groups to work cooperatively on the development of curricular materials, the education of teachers, and the decisions that are constantly being made concerning the teaching of science and mathematics. A number of the specific activities described above have had the closing of this gap as one of their objectives, and, as has been pointed out, have had some success in this direction.

In addition, representatives of the Science Teaching Improvement Program have taken part in a large number of local, regional, and national meetings that have had the improvement of relations between scientists and educationists as a goal and as an effect. Visits have been made to nearly 150 colleges and universities in the past 3 years to hold conferences and discussions and to give talks on teacher education problems. Representatives of STIP have attended meetings of more than half of the 41 academies of science affiliated with the AAAS, where they have presented papers, met with education committees of the academies, and helped to institute programs that have been followed up by various kinds of activities on the part of the academies. Papers have been prepared for publication and speeches have been given at meetings of a large number of educational associations and organizations.

With the existing decentralization of school control in the United States, the talk that goes on at national level about improving science and mathematics instruction has no effect until it gets translated into local action decisions. Much of the above-described effort has, naturally, consisted in encouraging and helping local groups to decide how they can work most effectively. One encouraging development is the inclusion in the 1959 budget of the National Science Foundation of money for grants to academies of science for science teaching improvement activities. The AAAS helped to stimulate the availability of this money and has consulted with many of the academies of science on the development of programs which might appropriately be supported by grants from it.

As a further effort in the direction of better cooperation between scientists and educationists, the Science Teaching Improvement Program appointed 20 regional consultants, university scientists interested in the improvement of education, who served through 1957 and the first half of 1958. Each worked within his region in much the same way that the small Washington STIP staff did on a national basis. Funds for their travel and expenses came from a grant to the Association from the General Electric Educational and Charitable Fund.

Particular mention should be made of advisory and consultative services in Washington, D.C. The Association has worked very closely with the National Academy of Sciences–National Research Council on a number of matters. The STIP staff has been available for frequent consultation with the National Science Foundation, the U.S. Office of Education, the President's Committee on Scientists and Engineers, and a large number of educational organizations.

Regional Action

The importance of action at the local community level has already been mentioned. As a special effort in this direction, the Science Teaching Improvement Program and the Educational Advisory Board of the National Academy of Sciences–National Research Council, with the financial support of the Hughes Aircraft Company, in 1957 planned and conducted at Lake Arrowhead, California, a conference of school administrators, scientists, and industrial representatives on the problems of industrial support for education. The conference was a highly successful one that led to the immediate creation of a local organization, financed by industry and directed by a science teacher released from a southern California school for that purpose, to coordinate the work of industry in providing equipment, summer position opportunities, and other aids to education. The conference served as a model for the President's Committee on Scientists and Engineers and became the basis for the extensive "local action" program of the President's Committee.

Special Activities

Of a number of special activities carried out during the past 3 years, four merit special mention. One was the holding of two conferences on mathematics instruction. The several organizations in-

terested in the improvement of mathematics instruction were all working quite independently. With the aid of a special grant from the Carnegie Corporation, two conferences of representatives of these organizations were held to discuss the problems in which all were interested.

Inclusion in the major education bills before Congress of provisions for assistance to the states on programs of student testing and guidance led to two simultaneous conferences in May 1958 of experts in testing and experts in student counseling. The purpose was to prepare recommendations that might be transmitted to state school officials for the improvement of their testing and guidance programs or the institution of such programs. The reports of the two groups are now available. The conferences were financed by a grant from the Carnegie Corporation and were planned with the cooperation of the American Personnel and Guidance Association and the American Psychological Association.

The large amount of interest in activities intended to interest children and high-school age youth in science led to the holding of a national conference of representatives of academies of science and junior academies of science. The conference provided an opportunity for exchange of information and ideas, and has resulted in the stimulation of increased activity on the part of state academies of science in providing programs of interest to elementary and high-school pupils. The national conference was supported by funds from the Oak Ridge Institute of Nuclear Studies and the National Science Foundation.

STIP has worked with a committee of teachers and parents in the Washington area during 1957–58 on planning for a course in science for grades 5 and 6, which is being offered by open-circuit television during this school year. The course has become a part of the science offerings for these grades in 16 school systems.

Information Newsletter

To help meet the need for exchange of information among the many organizations and agencies interested in the improvement of science and mathematics education, the Association's Science Teaching Improvement Program has prepared and circulated a semiannual newsletter reporting the science education activities of scientific societies and of a few government and industrial agencies.

Some Disappointments

Various things that those responsible for the Science Teaching Improvement Program and the Association's Cooperative Committee on the Teaching of Science and Mathematics had hoped to accomplish have not been done.

There was initially some hope that it would be possible to develop material that would be useful in interesting students in careers in science. After hundreds of samples of the literature already available for this purpose had been examined, it was decided not to enter this field.

We had hoped to make some direct contribution to the improvement of teachers' salaries and the betterment of their working conditions. Particularly disappointing has been inability to work effectively on our own or with other groups toward this goal.

When the Science Teaching Improvement Program was originally planned, it was hoped that one of its aspects could be a substantial national program of awards to outstanding high-school teachers of science and mathematics. The Association's officers were quite aware of the difficulties involved, but still believed that such an award program would constitute a useful part of the effort to enhance the prestige of competent teachers. Apparent success in securing financial support for such a program turned out to be illusory, and nothing more has been done on this aspect of the original Science Teaching Improvement Program.

News of Science

Evolution of the Organization of the Federal Government for Scientific Activities: the Beginning to 1947

In 1956 the Office of Special Studies of the National Science Foundation published a report which was titled *Organization of the Federal Government for Scientific Activities*. Part 1 of this report offers a brief examination of the history of the relationship between government and scientific activity in this country. Excerpts from this study are presented here. A second article will cover the period from 1947 to the present.

Early Organization

The Federal Government's organization for science began to take shape soon after the founding of the republic. It evolved slowly for the first hundred years, the pace quickening during the first part of the 20th century. Beginning in World War II, and continuing into the postwar period, there was a spectacular growth in the number and size of scientific agencies and in the scope and significance of their work.

This process of development has been paralleled by the growth of scientific activities in the nation at large. A phenomenal increase in the magnitude of the industrial scientific effort has occurred as industries which depend on technological progress have added to their scientific work, and as others which never before supported research have begun to do so. Basic research, too, has received increasing attention in industry.

The scientific activities of the Federal Government in the years before the Civil War consisted principally of the observation and collection of data about natural phenomena. The Naval Observatory, the Coast Survey, and the Army's Topographical Engineers were busily engaged in accumulating information to aid the nation's commerce and defense, and its westward expansion. The Smithsonian Institution, established in 1846, supported several important scientific activities which were later taken over

and conducted on a larger scale by other federal agencies.

The Civil War saw the creation of a quasi-governmental organization, the National Academy of Sciences, as a self-perpetuating body of distinguished scientists which was directed by law to study and report upon "any subject of science or art" when called upon by a government department. However, while some important new devices came into use during this conflict, relatively few civilian scientists undertook work on military equipment and weapons.

Post-Civil War Activity

In the half century following the Civil War, there was a steady growth in the Government's scientific effort, characterized by the expansion of data-gathering services undertaken in the public interest, such as the work of the Coast & Geodetic Survey, the Weather Bureau, and the Census Bureau. In addition a number of new scientific activities appeared which were designed to provide agencies with the data and materials needed in carrying out their responsibilities, such as the experimental work of the medical and signal activities of the Army and the analysis and testing work of the bureau of chemistry in the Department of Agriculture and at the National Bureau of Standards. The National Academy of Sciences was frequently called on to advise on the scientific problems faced by various departments.

Immediately before World War I, the establishment of the National Advisory Committee for Aeronautics (NACA) marked the beginning of a research program that was destined to pave the way for the development of new commercial and military aircraft in the years to come.

World Wars I and II

During World War I a new quasi-governmental organization, the National Research Council, was established by the National Academy of Sciences with the cooperation of national scientific and technical societies to make the nation's scientific resources more fully available to the Government.

In the period between the first and second World Wars, the Government's scientific activities expanded at an accelerated pace. Various Institutes of Health were created as part of the Public Health Service, and the federal medical research program grew rapidly. The War and Navy departments built a number of important new research installations. The social sciences began to play a role in the departments of Commerce, Labor, and Agriculture, and statistical and data collection activities and services were considerably expanded.

In World War II, several new organizational arrangements carried out the great bulk of all military research and development. These were principally the Office of Scientific Research and Development (OSRD) and its two major constituents, the National Defense Research Committee (NRDC) and the Committee on Medical Research; and the Manhattan Engineering District of the War Department's Corps of Engineers, which took over the research and development program on nuclear fission begun by NDRC. Each of these entities relied heavily upon contractual arrangements, primarily with university-based organizations, for the actual conduct of the wartime research and development projects which applied the scientific discoveries of recent years to military use. Military research and development in aeronautics was handled by an expanded National Advisory Committee for Aeronautics. This agency, whose former chairman, Vannevar Bush, became head of OSRD, provided a model for many aspects of the organization and operation of OSRD.

1945 to 1947

The termination of World War II was a critical occasion for the Federal Government's scientific activities. Popular understanding and acceptance of science stood at an all-time high, and scientists, as a result of their wartime accomplishments, enjoyed an unprecedented prestige. However, two important problems had to be faced.

Many of the civilian scientists in the Office of Scientific Research and Development were anxious to return to their peacetime pursuits, and the office began disbanding in 1945. The national security, nevertheless, required the continuance of some of the OSRD's major projects into the postwar period. Consequently, the military departments faced the problem of preserving the facilities, and at least a core of the personnel, engaged in these projects.

The status of basic research in the nation posed the other problem. It was widely recognized that wartime weapon developments had drawn heavily on the basic knowledge produced by the research of earlier years. European science, which had contributed much of our basic knowledge in the past, had suffered severely during the war. The Government's obligation to expand greatly its support of basic research was stressed in statements by key officials of the executive branch, and by scientists, businessmen, and others in congressional hearings.

The first problem was met in the postwar period by the transfer of a number of OSRD projects to the military department. For instance, the Air Force integrated personnel and equipment of the radiation laboratory at the Massachusetts Institute of Technology into its Cambridge Research Center.

Achievement of an adequate level of support for basic research proved to be a more difficult problem. In 1945 Vannevar Bush, the wartime director of the OSRD, submitted a report at the request of President Franklin D. Roosevelt on the steps needed to continue the nation's scientific advance. In his widely publicized report, *Science—The Endless Frontier,* Bush proposed the establishment of a National Research Foundation to support research and education in the sciences and dissemination of scientific information.

The principal federal support for basic research in the years immediately following the war came from the Navy Department, which set up the Office of Research and Inventions in 1945. In 1946, by act of Congress, this became the Office of Naval Research which supports basic research in the many scientific fields of interest to the Navy.

Another major source of support for such research was the National Institutes of Health. From the Atomic Energy Commission, an agency also established in 1946, came other funds for the support of basic research. In 1947, President Truman, recognizing the need for a full examination of the nation's scientific research effort, established an *ad hoc* body, the President's Scientific Research Board, under the chairmanship of his adviser, John R. Steelman.

Archeology in the Upper Nile

When the Aswan dam in Egypt is completed—and the Soviet Union has promised the United Arab Republic that it will help finance the project—a storage basin more than 300 miles long will engulf the temples and burial grounds of the early rulers of Nubia dating back to 4000 years before Christ. Six thousand years of recorded history of the life of man along the upper Nile in Egypt and the Sudan will be deep under water in 4 or 5 years.

To save as much as possible of the record, the Department of Antiquities of the Egyptian Government this spring asked all governments and acheological groups that had shown an interest in Egypt to concentrate their efforts for the next few years in the upper Nile Valley. The response has not been very encouraging, for there have been only five affirmative replies. These came from the United States, Italy, West Germany, Poland, and the Soviet Union. The American response came from Brown University. Brown is sending an expedition, under Ricardo Caminos, to take

over a photographing program that was begun by a British group, but which had to be abandoned after the attack on Suez by Britain, France, and Israel in 1956.

Egypt herself is sending out two expeditions to the area this year, and the United Nations Educational, Scientific and Cultural Organization has had a photographic program in progress for several years.

Some of the smaller temples, such as those to Isis at Philae, just above Aswan, could be taken down and reassembled elsewhere. An Egyptian survey team recommended that this be done 2 years ago. Two of the most beautiful of the temples along the Nile will be lost. They are the two at Abu Simbel, above the second cataract, that were carved out of the mountainside during the reign of Rameses II (1300–1234 B.C.), greatest of the early Pharaohs. It is these that the UNESCO team, under the direction of Mme. Desroches-Noblecourt of France, is attempting to photograph by a three-dimensional process. Mme. Desroches-Noblecourt is director of the Egyptian section of the Louvre in Paris. The photogrammetric process records accurately to fractions of a centimeter.

The losses on the Sudanese side of the twenty-second parallel, the dividing line between the two countries, will be even greater than those in Egypt. Much less work has been done there.

Implementation of the National Education Act

The Council of Chief State School Officers sponsored a conference at Michigan State University, 3–5 November, to develop guidelines for use by state educational agencies in determining standards for science, mathematics, and modern foreign languages. John R. Mayor, AAAS director of education, served as director of the conference, and William Haskell of the *Science* editorial staff was one of the two writers assigned to prepare a conference report that will be given wide distribution.

The conference was held to aid state administration of federal funds rceived under Title III of the National Defense Education Act of 1958. The meeting was supported by the Educational Facilities Laboratories, an organization that was established recently by the Ford Foundation to promote better education through improved physical facilities.

Title III authorizes the spending of $61,600,000 per year in federal funds, to be matched by equal state expenditures, in grants to the states for the acquisition of laboratory and other special equipment for science, mathematics, or modern foreign language teaching in public elementary and secondary schools, and for minor remodeling of laboratory or other space to be used for such equipment. Funds will also be provided for "expansion or improvement of supervisory or related services in public . . . schools in the fields of science, mathematics, and modern foreign languages."

The U.S. Office of Education will administer the Title III program. State educational agencies will prepare plans for the use of federal funds in schools of their states and submit them to the U.S. Commissioner of Education for approval.

In addition to sponsoring the Michigan conference, the Educational Facilities Laboratories has announced the award of its first grant to aid implementation of the Education Act. A grant of $75,850 will support a nationwide study to determine what constitutes good design for physics building facilities. The 18-month study, which will begin in January 1959, is to be conducted under the joint auspices of the American Association of Physics Teachers and the American Institute of Physics.

Detailed information about existing physics facilities will be collected by questionnaire in a preliminary survey. It is anticipated that the results of the study will be made available to building planners as a series of booklets dealing with different facets of physics building design, microfilm records of photographs and building plans, and check lists. The records of the project will be stored in some central location for use by physicists and architects.

OEEC Summer School for Science Teachers

The second of the three pilot vacation courses for organizers of refresher courses for science teachers, arranged by the Office of European Economic Cooperation's Office for Scientific and Technical Personnel, was held at the Politische Akademie, Tutzing, near Munich, 4–15 August. Forty-five science teachers from 13 OEEC member countries, the United States, and Spain attended the course, which was designed to enable them to run similar courses for science teachers in their own countries.

The program included lectures and discussions on the teaching of physics, chemistry, and biology, with emphasis on how new and interesting types of classroom experiments can be arranged for school children. Special attention was also given to methods of incorporating nuclear physics into the teaching of school science. A third theme was the use of new methods, such as radio, television and films, in science teaching. The course was directed by Erich Baumann and Frank Ebner of the Bavarian Teachers' Association.

A third course in this series, which is planned by the OEEC as part of its drive to overcome the European shortage of scientists and technicians, is taking place in Paris this month.

News Briefs

The important role of Washington, D.C., in the development of the science of anthropology over the past 150 years is the subject of a special 2-month exhibition that opened this month in the Smithsonian Institution's Natural History Building. It portrays the contributions of many federal agencies and private Washington institutions to the fields of archeology, ethnology, linguistics, and physical anthropology. Sponsored jointly by the Smithsonian, the Library of Congress, and the Anthropological Society of Washington, the exhibition was planned to coincide with the November annual meeting of the American Anthropological Association and the AAAS annual meeting in December.

* * *

The first English translation of the Russian journal *Geokhimiya* has been released by the Geochemical Society, which plans to issue the journal regularly eight times a year. The project is aided by a grant from the National Science Foundation. The success of the venture will depend in large part on the number of subscriptions sold. The subscription price is $20 per year, $10 to educational institutions and to members of the Geochemical Society. For information, write to the managing editor, E. W. Heinrich, Mineralogical Laboratory, University of Michigan, Ann Arbor, Mich.

* * *

New facilities for studies in mathematics and physics at California Institute of Technology have been assured by a grant of $1,165,700 from the Alfred P. Sloan Foundation of New York. The gift will finance the remodeling of a building which for many years has housed the institute's experimental high voltage laboratory. This will become a modern five-story structure and will be renamed the Alfred P. Sloan Laboratory of Mathematics and Physics.

* * *

A simplified method of predicting satellite courses has been published for the benefit of volunteer observers by the National Academy of Sciences. With this manual, volunteers can utilize simple orbital elements—such as inclination of the orbit plane to the equator and distance to the center of the earth at the low point of orbit—to figure out where to

from the National Science Foundation, given locality. *Simplified Satellite Prediction From Modified Orbital Elements* may be obtained for $1 from the Publications Office, National Academy of Sciences, Washington 25, D.C.

* * *

An exhibit of paintings, drawings, and prints illustrating "Art in Science" is being displayed at the International Business Machines Gallery of Arts and Science in New York, 11–26 November. The exhibit, sponsored by the *Scientific American*, is composed of covers and illustrations drawn for the magazine. The American Federation of Arts assisted in the preparation of the exhibit.

* * *

Apparatus has been developed at the National Bureau of Standards by F. E. Washer that makes possible the rapid, accurate visual testing of high-precision lenses, such as those used in airplane cameras and telescopes. Spherical and chromatic aberration are determined on an optical T-bench equipped with nodal slides and angle-measuring telescope. From the resulting data, corrections are easily made for out-of-focus effects.

* * *

An explanation of what cosmic rays are and how they were discovered will be shown on television again when "The Strange Case of the Cosmic Rays" is repeated on the National Broadcasting Company at 6 P.M. on 23 November as a part of the Bell System Science Series.

* * *

The National Science Foundation has issued a compilation of the Soviet scientific and technical journals available in English translation in the United States. There are now in print 53 English editions of Russian journals, four extensive series of translated Russian abstracts of scientific papers, and four series of partial translations of important Russian journals. The number of translations of complete journals supported by the National Science Foundation is 31.

Grants, Fellowships, and Awards

Atomic Energy. Graduate students who wish to major in subjects within the field of nuclear science and engineering are eligible to apply for special Atomic Energy Commission fellowships to support such studies. Up to 150 appointments will be made for fellowships which begin in the fall of 1959. More than 40 universities in the United States offering the required courses accept students under this program.

Basic stipend for first-year students is $1800 for 12 months. Intermediate-year fellows receive $2000, and terminal-year appointees, $2200. An additional allowance of $500 per year is made for a wife and a maximum of two dependent children, and tuition, fees, and travel allowances are provided.

The Oak Ridge Institute of Nuclear Studies, which administers these fellowships for the commission, has established an application deadline of *2 January 1959*. Brochures and application materials are available on request from the Nuclear Science and Engineering Fellowship Office, University Relations Division, Oak Ridge Institute of Nuclear Studies, Box 117, Oak Ridge, Tenn.

Biological Sciences. The Division of Biological and Medical Sciences of the National Science Foundation has announced that the next closing date for receipt of basic research proposals in the life sciences is *15 January 1959*. Proposals received prior to that date will be reviewed at the spring meetings of the foundation's advisory panels and disposition will be made approximately 4 months following the closing date. Inquiries should be addressed to the National Science Foundation, Washington 25, D.C.

Teacher training. Stanford University, with the financial support of the Shell Companies Foundation, is again making available to secondary-school chemistry, physics, and mathematics teachers in the United States and Canada 50 Merit Fellowships which provide an opportunity for advanced study. The Shell program makes it possible for a teacher to attend a Stanford University summer session with practically no cost to himself. The fellowships provide full tuition, board, and room; textbook and travel allowances; and a cash stipend of $500. The total value of a fellowship is approximately $1250 for the 8-week summer session. The application deadline is *1 January 1959*. For information, write to: Dr. Paul DeH. Hurd, Coordinator, Shell Merit Fellowship Program, School of Education, Stanford University, Stanford, Calif.

Travel grants. The National Science Foundation will award individual grants to defray partial travel expenses for a limited number of American scientists who wish to participate in the following international congresses: International Congress of the History of Science, Barcelona, August-September 1959; International Sociological Association Congress, Perugia, September 1959; International Union for the Scientific Study of Population, Vienna, August-September 1959; and the Pan–African Congress on Prehistory, Leopoldville, August 1959.

An attempt will be made to have the grants approximate round-trip air tourist fare between the scientist's home institution and the location of the meeting. Application blanks may be obtained from the National Science Foundation, Washington 25, D.C. Completed application forms must be submitted by *1 February 1959*.

Scientists in the News

EUGENE P. WIGNER, Thomas D. Jones professor of mathematical physics at Princeton University, is to receive the Atomic Energy Commission's Enrico Fermi Award. The $50,000 award will be presented to Wigner on 2 December for "contributions to nuclear and theoretical physics, to nuclear reactor development, and to practical applications of atomic energy."

The presentation ceremony is being held on the anniversary of the day when the late Enrico Fermi and his associates. among them Wigner, proved that nuclear fission could be self-sustained and controlled. This year's ceremony marks the 16th anniversary of the start-up, in 1942, of the first nuclear reactor under the stands of Stagg Field at the University of Chicago.

The award was recommended by the AEC's General Advisory Committee and approved by President Eisenhower. The Advisory Committee's recommendation was contained in a letter, dated 7 August, from the committee's chairman, Warren C. Johnson, to AEC chairman John A. McCone. After reporting that it was the unanimous recommendation of the committee that the award be made to Wigner, the letter reads:

". . . Dr. Wigner is one of the most renowned authorities in theoretical physics. His contributions have been both numerous and outstanding in the field of nuclear physics but have not been limited to this field; on the contrary, they have embraced many areas of theoretical physics.

"Dr. Wigner was the first to calculate, and with unusual accuracy, the correct lattice proportions of uranium and graphite in the design of the Hanford production piles. He also predicted the dislocation effect caused by fast neutrons in graphite, and designed experiments to verify his prediction. As a consequence, we were forewarned at an early date of a very serious problem in the operation of graphite piles. Also it was largely due to Dr. Wigner's insistence that the water-cooled design for the Hanford piles was adopted instead of other concepts. This decision was of the greatest importance in insuring the necessary production of plutonium during the war and the years to follow.

"During the past decade or so, Dr. Wigner has made numerous contributions to the development of nuclear reactors, both for military and civilian purposes. Also, he has been responsible for the

training of many scientists and engineers in the field. There is no one in the country today who is better informed about the reactor development program and has made more contributions to its progress than has Dr. Wigner.

"Dr. Wigner's contributions to the theory of nuclear reactions in the energy range of interest for reactors, as well as for nuclear reactions in general, lie at the foundation of what has now come to be called classical nuclear physics.

"Furthermore, it is especially appropriate to emphasize that although Dr. Wigner is rightfully regarded as a theoretical physicist, his contributions have been outstanding in the practical developments of nuclear energy. In this respect his dual role in the atomic energy field is quite unique."

Wigner is the third recipient of the Enrico Fermi Award. The late John von Neumann, noted mathematician and member of the Atomic Energy Commission, became the first recipient when the award was presented to him in April 1956. The late E. O. Lawrence, inventor of the cyclotron, was the second.

Fermi himself was the first to receive an award conferred under authority of the Atomic Energy Act of 1954. He was honored, on recommendation of the General Advisory Committee, in November 1954. When von Neumann was chosen to receive the award in 1956, it was decided that the award henceforth should bear Fermi's name.

The Gairdner Foundation, Toronto, Canada, has announced its first International Awards in Arthritis and Heart Disease, totalling $40,000. Medical scientists from England, the United States, and Canada are included among the seven recipients.

The $25,000 Gairdner Foundation Award of Merit has been awarded to ALFRED BLALOCK, professor of surgery at Johns Hopkins University, and HELEN B. TAUSSIG, associate professor of medicine at Johns Hopkins University, for their initial development of what is known to the public as the "blue-baby operation."

Three Gairdner Foundation Annual Awards of $5000 each have been awarded to the following:

HARRY M. ROSE, professor of medical and surgical research at Columbia University, and CHARLES RAGAN, professor of clinical medicine at Columbia University, for their discovery of the first practical laboratory test for the diagnosis of rheumatoid arthritis.

W. D. M. PATON, professor of pharmacology at the Royal College of Surgeons, London, and ELEANOR ZAIMIS, professor of pharmacology at the Royal Free Hospital School of Medicine, London, for their discovery of the first drugs to be proved practical and effective in treatment of high blood pressure.

W. G. BIGELOW, associate professor of surgery at the University of Toronto, Toronto, Canada, for his development of the technique of hypothermia for heart surgery.

The Gairdner Foundation was incorporated in December 1957. Its funds derive from personal gifts of J. A. Gairdner, a Canadian industrialist and financier, and members of his family. Gairdner was president of the Canadian Arthritis and Rheumatism Society from 1949 to 1952 and chairman of its National Board of Directors from 1952 to 1958.

The awards are prizes for achievements and not grants for support of future research. They are intended to encourage and reward individuals who have made major contributions to the conquest of disease and human suffering, to help focus attention on the problems of arthritis and heart disease, and to facilitate communication of ideas among scientific workers in these fields.

The $25,000 Award of Merit is to be presented periodically to the individual or group who, in the opinion of the foundation, has made outstanding discoveries or contributions in the same fields.

ROGER ADAMS, research professor of chemistry at the University of Illinois, has won the American Chemical Society's Charles Lathrop Parsons Award for outstanding public service. Adams is widely known for his services to the government, his research on medicinals, and his achievements in science teaching. He is a former president of the AAAS and of the American Chemical Society.

The Parsons Award, which cannot be given more frequently than once every 3 years, consists of a scroll and the privilege of choosing the recipient of a $2000 scholarship for graduate study in chemistry, chemical engineering, or some related field. The award will be presented to Adams at a dinner in conjunction with the quarterly meeting of the ACS Board of Directors on 6 December in Washington, D.C.

DELL LEBO, associate professor of psychology at Richmond Professional Institute of the College of William and Mary, has accepted an appointment to the staff of the Child Guidance and Speech Correction Clinic of Jacksonville, Fla. He will also serve as lecturer in psychology at Jacksonville University.

A. BAIRD HASTINGS, chairman of the department of biological chemistry at Harvard Medical School, will retire on 31 December after 23 years of teaching at Harvard. He becomes Hamilton Kuhn professor of biological chemistry, emeritus. On 1 January 1959, Hastings will join the Scripps Clinic and Research Foundation at La Jolla, Calif., as a member of the resident research staff. He plans to continue his current interests in intermediary metabolism and in the application of biochemistry to the study of disease.

Hastings early recognized the value of radioactive isotopes in medical research and took an active role in the establishment of the first laboratory to use these nuclear tools at the Harvard Medical School. This laboratory in 1946 became the Biophysical Laboratory in the Medical School.

Hastings' early work was with Donald D. Van Slyke, one of the founders of biochemistry, at the Rockefeller Institute for Medical Research. There, from 1921 to 1926, he carried on research on the extracellular fluids of the body, especially on electrolytes of the blood. In 1925 he was an assistant to the German biochemist Otto Warburg while the latter was at the Rockefeller Institute. Later, he spent several months with Warburg at the Kaiser Wilhelm Institute for Biology at Dahlem, Germany.

Hastings was appointed professor of physiological chemistry at the University of Chicago in 1926, and in 1928 became professor of biochemistry in the department of medicine and director of the Lasker Foundation for Medical Research there. At Chicago he taught both graduate and medical students while carrying on research on edema and adrenal disorders. His work there in defining the principles which determine water and electrolyte exchange between blood and tissues has found widespread application in clinical medicine. He joined the faculty of medicine at Harvard in 1935 as Hamilton Kuhn professor of biological chemistry and head of the department.

The research carried out at Harvard in collaboration with his students and colleagues has included biochemical changes in aging, the metabolism of carbohydrates, the role of hormones in metabolism, and factors affecting bone formation.

In his academic career, Hastings also has served as lecturer at the University of Southern California (1929); as visiting professor of biochemistry at the Peiping Union Medical College (1930–31); as visiting scientist at the Carlsberg Laboratory, Copenhagen (1950); as Fulbright lecturer at Oxford University (1952); and as visiting professor at the John Curtin School for Medical Research, Australian National University, Canberra (1957).

Hastings received the B.S. degree from the University of Michigan in 1917 and

the Ph.D. degree from Columbia University in 1921. He holds the honorary doctorate of science from Michigan (1941), Harvard (1945), Oxford (1952), and Boston (1956). In 1957 he was named honorary professor at the University of San Marcos, Lima, Peru.

Upon recommendation of the School Science Committee, the American Academy of Arts and Sciences at its meeting of 12 November presented the following nine teachers with Elizabeth Thompson Awards for outstanding science teaching in the secondary schools of New England: FREDERICK AVIS, head of the science department, St. Mark's School, Southborough, Mass.; ROGER BARTON, teacher of science, Orleans High School, Orleans, Vt.; FLORENCE HANCOCK, teacher of mathematics, Peterborough Consolidated School, Peterborough, N.H.; DOROTHY HARLOW, teacher of biology, Rockville High School, Rockville, Conn.; SANTO MARINO, teacher of science, Lexington Junior High School, Lexington, Mass.; ELIZABETH A. QUINN, teacher of science and assistant principal, Saxe Junior High School, New Canaan, Conn.; MARY C. ROGERS, science teacher, Thompson Junior High School, Newport, R.I.; LOUISE SWENSON, teacher of biology and chemistry, Lynn English High School, Lynn, Mass.; FRED L. TURNER, submaster and head of the science department, Cony High School, Augusta, Me.

Three pioneers of glass research were honored recently at a dinner at the Corning Glass Center, Corning, N.Y. EUGENE C. SULLIVAN, the late WILLIAM C. TAYLOR (see "Recent Deaths," this issue), and JESSE T. LITTLETON received the tribute of 85 fellow research scientists and engineers during an informal program commemorating the 50th anniversary of Corning's research laboratories.

Sullivan, dean of glass scientists, founded the Corning laboratory in 1908. The staff conducted the first organized glass research program in the United States and was one of the first industrial laboratories in the country.

Taylor joined the staff later in 1908 as a chemist. Together with Sullivan, he conducted research that led to the perfection of heat- and corrosion-resistant borosilicate glasses.

Littleton joined the laboratory in 1913 as the first physicist on the staff. He was responsible for developing glass cooking ware that was marketed under the Pyrex brand name.

The U.S. Navy's highest civilian honor has been awarded to EDGAR H. DIX, JR., retired assistant director of research, Aluminum Company of America. In ceremonies held at the Pentagon in Washington, D.C., Garrison Norton, Assistant Secretary of the Navy (Air), presented Dix with the Distinguished Public Service Award. The citation states, in part:

"As assistant director of research of the Alcoa Research Laboratories of Aluminum Company of America, Dix was the guiding intellect in the development of high strength, corrosion resistant aluminum alloys which constitute the basic construction material in modern, high performance naval aircraft. Dix has devoted a lifetime to aviation in general; and naval aviation, in particular, has benefited greatly from his achievements. His vision, technical competence and efficient leadership have resulted in outstanding contributions to the nation's defense capability."

Recognized internationally as the dean of aluminum metallurgy, Dix retired from Alcoa on 1 September, following 40 years of service with the firm. He has been directly or indirectly responsible for the development of the majority of the aluminum alloys in use today.

A portrait of FRANCES R. HOUSTON was presented to the University of Pennsylvania on 6 November in recognition of her 40 years of service to medical students, faculty, and alumni as librarian of the university's School of Medicine. The 1958 medical class started the movement to obtain funds for the portrait. With the enthusiastic help of faculty and alumni, the necessary amount was quickly subscribed, and artist Pietro Pezzati, of Boston, was commissioned. The portrait has been hung in the Medical Library among those of many distinguished university medical educators of the past.

JOSEPH V. CHARYK has been appointed chief scientist of the United States Air Force. Charyk, general manager of the Space Technology Division of Aeronutronics Systems, Inc., a subsidiary of Ford Motor Company in Glendale and Newport Beach, Calif., succeeds G. E. VALLEY. Valley has accepted a position with Melpar, Inc., a subsidiary of Westinghouse Air Brake Co., Falls Church, Va.

FRANK K. PITTMAN has been appointed director of the Atomic Energy Commission's Division of Reactor Development, which now has responsibility for the functions previously assigned to the Office of Industrial Development, except for those having to do with isotope development. Pittman has been director of the Office of Industrial Development since it was established in December 1957.

In addition, ALLEN J. VANDER WEYDEN, former deputy director of the Division of International Affairs, has been named deputy director of the Division of Reactor Development.

The functions of isotope development have been placed in an Office of Isotope and Radiation Development, which is headed by Paul C. Aebersold.

Recent Deaths

DONALD GUTHRIE, Sayre, Pa.; 78; founder of the Guthrie Clinic and chief surgeon of Robert Packer Hospital; retired professor of surgery at the University of Pennsylvania School of Medicine; chief surgeon of the Lehigh Valley Railroad for 30 years; helped to organize the American Board of Surgery; 31 Oct.

PAUL U. KELLOGG, New Paltz, N.Y.; 79; for 40 years editor of *The Survey*, a sociological journal that was discontinued in 1952; led an investigation, 1907–09, of the Pittsburgh steel industry, the first such social survey, and revealed facts which contributed to the abolition of the 7-day week and the introduction of the 8-hour day in industry; 1 Nov.

JACKSON O. KLEBER, Whitestone, Queens; 58; director of research of the National Industries for the Blind and former chief engineer of the Talking Book studios of the American Foundation for the Blind; inventor of a number of devices to aid the blind, including a device with which the deaf-blind can communicate; 30 Oct.

LOUIS LAHN, Norwich, Conn.; 63; clinical professor of obstetrics and gynecology at New York Polyclinic Medical School and Hospital; associate professor of obstetrics and gynecology at the New York Medical College; associate gynecologist at the Hospital for Joint Diseases; 31 Oct.

ROBERT T. MOORE, Los Angeles, Calif.; 76; ornithologist and retired research associate professor in vertebrate zoology, California Institute of Technology and Occidental College; director of the Moore Zoological Laboratory at Occidental; led several ornithological expeditions to Ecuador and Mexico; 30 Oct.

JOHN F. STIMSON, Papeete, Tahiti; 75; noted Polynesian ethnologist; editor for Polynesia of *Webster's Dictionary;* author of the Tahitian-English and Tuomatuan dictionary; 19 Oct.

WILLIAM C. TAYLOR, Corning, N.Y.; 72; honorary vice president and general adviser of the Corning Glass Works, with which he had been associated for 50 years; coinventor of Pyrex, heat-resistant glass; holder of 32 patents; 2 Nov.

Book Reviews

Clarence King. A biography. Thurman Wilkins. Macmillan, New York, 1958. xii + 441 pp. $7.50.

There is a dashing quality to the figure of Clarence King exploring the high Sierras at 20 and leaving Washington at 24 as United States Geologist in charge of the Fortieth Parallel Survey—a commission which Secretary Stanton told him was wanted by four major generals. King thirsted for adventure, whether it was hunting buffaloes, outwitting Apaches, or wrestling fever in Nicaragua or "old gold girls" in Hawaii. He went down the mines at Butte impeccably attired in clothes freshly cleaned and pressed by his valet. Henry Adams deferred to him on matters of art and poetry. He visited a Cuban revolutionary in a cell at Santiago and dined with Henry James in London. Perhaps he described pursuing a grizzly into a mountain cave in the tête-à-tête he held with the Prince of Wales at "Ferdy" de Rothschild's.

King was an expert witness, whose appearance in many a Western courtroom brought certain victory for his mine. He moved freely between the saloons of Leadville and the Players or the Century in New York. King at 30, exposing the great diamond hoax, might have been invented by Walter Mitty or a Douglas Fairbanks script-writer: "There's not enough money in the Bank of California to make me delay publication a single hour. If you don't publish, *I* will. But it will come with much better grace from you."

Clarence King led two lives in more than one sense. In his young-manhood he joined with Whitney and Powell and Emmons in the great period of the geological exploration and discovery of the American West. This carried him to fame and the directorship of the then new United States Geological Survey. But he resigned his post after a year of solid accomplishment to devote himself to "expertizing" and the promoting of mines and of himself. King was the golden boy who lived on into the gilded age, and the ambiguities of the period were reflected in the man. When he left the august company at Roosevelt's Boone and Crockett Club, or Pierre Lorillard's Tuxedo, it was to slip into Brooklyn as James Todd, a porter, to visit his Negro wife and children.

Thurman Wilkins has written a careful and meticulous account of "the most remarkable man of our time." How did it happen, asked Henry Adams, that he could leave no more trace than one of Walcott's fossils? King emerges somewhat pale and shaken from the pages of this biography, which gives a sober, scholarly, and disquieting view of one man's headlong flight into oblivion.

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Particulate Clouds: Dusts, Smokes and Mists. Their physics and physical chemistry and industrial and environmental aspects. H. L. Green and W. R. Lane. Van Nostrand, Princeton, 1957. xix + 425 pp. + plates. Illus. $11.25.

This treatise on particulate clouds originated at the Chemical Defense Experimental Establishment at Porton Downs, England. Sir Harold Hartley, in the foreword, points out the important role which this chemical warfare station has played in the development of protective measures against smokes, as well as in the production of protective smokes. The authors and their colleagues have, in their fundamental work on particulates, contributed to various sampling techniques, production of particles of uniform size and atomization, production of high-efficiency filters for protection in dusty operations and in atomic energy establishments, and development of spray methods for insect control.

The book is a most valuable account of the scientific studies and practical applications in this field, and only the personal contact which the authors have had, over many years, with its development has made this possible.

The first part of the book contains studies on the basic physics and physical chemistry of particulate clouds and treats them as unified systems, since many different types of clouds have essentially the same properties. In eight chapters the production of particulate clouds, their physical characteristics, coagulation, deposition and filtration, analysis, and diffusion in the atmosphere are discussed.

The second part illustrates a number of practical implications of part I and goes into somewhat more detail on technical and practical matters. For example, the chapter on collection discusses cyclones, scrubbing, electrostatic precipitation, and filtration methods of many kinds. The second part contains, in addition, chapters on health hazards, atmospheric pollution, aerosols in nature, and the uses of particulate clouds for signal smokes, therapeutic purposes, and industrial applications.

A textbook of this kind, which must have required many years of careful preparation, could not be expected to be completely up to date in this rapidly moving field. Neither does it pretend to be all-inclusive. It provides, however, a background for more intelligent sorting of the flood of articles published by air-pollution agencies.

The concern which the authors express about the vast and scattered literature on particulates and its sometimes unwarranted growth is shared by many in the field of air pollution. By bringing together most of the topics on particulates, and supplying a thorough literature reference list after each chapter—thereby providing opportunity to obtain more details if desired—the authors have done a real service to the worker in this field.

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Chemical Publications, Their Nature and Use. M. G. Mellon. McGraw-Hill, New York, ed. 3, 1958. x + 327 pp. Illus. $7.

When one sees an old friend in the form of a textbook newly revised after nearly 20 years, he naturally wants to know what is new and what has stayed the same. This review will attempt to answer the question for Mellon's new edition.

The framework of the book remains essentially the same as that of the second edition, but this volume is about 45 pages longer. It is a tribute to the careful writing and organization to note that a good deal of the text, perhaps one-half, has been carried over unchanged.

Almost all of the important book and periodical lists have been done over, however, with old material included where it is still pertinent and recent publications added where they are significant. Some of the latter are dated 1957.

Mellon has rewritten and expanded the central section of the book, chapters 8 through 10, the latter chapter being a new addition. This has made an important topic, "Secondary and tertiary sources," more accessible to the student, and this chapter will undoubtedly be used for reference itself.

The final text chapter, "Making searches in the chemical literature," has probably been changed the least of any, but in this case lack of change is to be regretted. There has been a great deal of material published on how to make searches, and much of it is pertinent here. Several dozen references are given en bloc to papers on the subject in various numbers of the *Advances in Chemistry* series, but they have not been worked into the text.

The library problems, as before, constitute a thorough coverage of the material given earlier in the text. Most of them include new examples.

The index has grown about one-third but still omits names appearing in footnotes or reference lists.

The following remarks are offered in a helpful spirit and are not meant to detract from an excellent textbook. The *Bulletin analytique* is now *Bulletin signalétique*. I believe the *Ref. Zhur. Khim.* should be included as a searching possibility, despite the lack of subject indexes (page 230). Its name is misspelled on page 105 and in the index. A footnote on page 59 includes a misprint: "No. 4" is given, but "No. 10" is meant. UNESCO has done so much work with language dictionaries that some reference to it could well be included on page 191.

KARL F. HEUMANN
Chemical Abstracts,
Columbus, Ohio

Logical Design of Digital Computers. Montgomery Phister, Jr. Wiley, New York; Chapman & Hall, London, 1958. xvi + 408 pp. Illus. $10.50.

No previous knowledge of computers is assumed by the author of this introductory text, which is well adapted for independent study or for a one- or two-semester course. Its 12 chapters and two appendices cover general methods and techniques, not details of a particular computer with which the author has been associated. Almost every chapter has a collection of exercises and a selection of references quite adequate to lead the student further into the field. There are also many worked-out examples. In general, the book is easy to understand, and though the mathematical discussion may not seem particularly elegant to the mathematician or physicist, it compares very favorably with those generally found in engineering texts.

The first two chapters give a bird's-eye view of digital-computer design, circuit components, and binary numbers. One needs hardly more than the names of circuit components and a brief description of how they behave for logical design for a general understanding of these subjects, so the reader need have no previous knowledge of them. The next two chapters deal with Boolean algebra and the simplification of Boolean functions. The rest of the book cannot be understood without a knowledge of the content of these chapters. Boolean algebra is the algebra of logic and of relay circuits, and while computers can be designed without it, the intricacies of modern computers and the logical properties of circuit elements have now become so complicated that the designer of computers would be like a mathematician without the convenience of algebraic notation if Boolean algebra were not available. Actually, Boolean algebra is inherently simpler than even high-school algebra, and the reader with modest mathematical attainments can master the material, even though the text sometimes will make him sweat.

The next chapter deals with the logical equations characteristic of memory elements [computers are essentially memory elements connected by decision elements (which were discussed along with Boolean algebra), decisions being made between "true" and "false," say] and shows how memory elements are connected to carry out a given operation. Greater generality is reached in the following chapter. The seventh chapter gives a survey of computer memories of large capacity (as distinguished from the one-bit or yes-or-no memories discussed earlier), which can be read or erased or have more information written into them. Input-output equipment, by which information is fed to or taken from the computer, is discussed next.

Chapter 9, on the arithmetic unit, shows how memory and decision elements are designed into circuits capable of carrying out the simple arithmetical operations and the logical operation of comparison. It is the longest chapter in the book and deals with many of the most important and ubiquitous problems of computer logical (not engineering!) design. Much of the technical jargon of the computer art can be learned from this chapter. The next chapter briefly treats error-detecting codes applied to error prevention in computers. Chapter 11 ties all the pieces together by applying the principles earlier expounded to the design of two simple computers, one of general-purpose, the other of special-purpose, design. The last chapter very briefly touches on the ways in which the gaps between the logical equations and actual construction, and between construction and operation, are bridged.

To sum up, the book is a good introduction, can be read fairly easily by engineers, physicists, mathematicians, or logicians with only undergraduate training, gives an adequate guide to the literature for further study, and would equip someone willing to work out the exercises with sufficient facility in logical design to qualify him for work in a logical-design group.

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Surface Active Agents and Detergents. vol. II. Anthony M. Schwartz, James W. Perry, Julian Berch. Interscience, New York, 1958. xv + 839 pp. Illus. $17.50.

Since the late '30's, the field of surface-active agents has expanded almost explosively. In 1949 Schwartz and Perry published *Surface Active Agents: Their Chemistry and Technology,* which was a notably successful attempt to cover the field up to 1947. The present volume attempts to extend this coverage through 1956. Because of the extremely rapid development of the field (the patent and technological and scientific literature since 1947 far exceeds that available before then), the present book supplements rather than replaces the original and is hence designated volume 2.

The material presented is divided into four major subdivisions: "Processes for synthesizing and manufacturing surfactants," "Special function surfactants and compositions," "The physical and colloidal chemistry of surfactants in theory and practice," and "Practical applications of surfactants." Each of these sections is very well referenced, and this is perhaps the most useful aspect of the book. Because of the mass of material covered, only brief mention is made of each of the many topics in each section of the book. However, the inclusion of a very complete bibliography serves as compensation.

As can be seen from the book's major subdivisions, the authors are concerned primarily with the technology rather than the science of surface-active agents, and hence the book should be most useful for those whose major concern is syntheses of new materials or product development, or both. Nevertheless, the fundamentals are not completely overlooked.

The section on the physical and colloidal chemistry of surfactants rightfully

does not concern itself only with the surface-active agent. A brief section on recent advances in surface physics tends to emphasize the important role played by the substate in phenomena involving surfactants. The bulk properties of surface-active agents, particularly the formation and structure of micelles, are given good coverage.

Because of its encyclopedic coverage and extensive bibliography, volume 2 of *Surface Active Agents and Detergents*, by Schwartz, Perry, and Berch, should be a valuable addition to the library of anyone whose work requires an up-to-date knowledge of this important and active field of technology.

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Thinking. An experimental and social study. Frederic Bartlett. Basic Books, New York, 1958, 203 pp. $4.

This highly readable little book represents another example of the characteristically British trait of performing interesting psychological research with relatively simple methods, in contrast to the American trend toward increasing dependence on complex mathematical and electronic techniques. It reports the outcome of 25 years of Bartlett's own thinking about thinking and is intended to be neither an exhaustive survey of the field nor the final report of an organized research program.

Bartlett's approach incorporates several unique features. He conceives of thinking as an advanced form of "bodily skill," to be most fruitfully studied in terms of what is known about the latter. The book is divided into two sections. The first is concerned with thinking within "closed systems," in which a limited number of "items" is involved. Most of Bartlett's experimental work is included here. Chapters on experimental, everyday, and artistic thinking constitute the second section (entitled "Adventurous thinking"), which includes primarily biographical and case material.

Semantic confusion results from Bartlett's definition of thinking as "the extension of evidence in accord with that evidence so as to fill up gaps in the evidence." This brings into the fold much of the work on perception, as well as Bartlett's own classic work, *Remembering*. In contrast with the most common usage, thinking is distinguished from problem-solving in that the latter is said to be concerned only with behavior directly associated with the solution to a problem.

The space devoted to reports of experiments seems uneven; I found myself wishing for more detailed descriptions of procedure and results in some instances and for the omission of lengthy protocols in others. Those researchers on complex mental processes who find straightforward conclusions exceedingly difficult to come by may be somewhat skeptical of the sweeping general statements made with respect to the results of some experiments. Unfortunately almost no effort is made by Bartlett to relate his work to similar work in other laboratories.

Thinking will undoubtedly be most useful to those who are active in this line of research, as a stimulant for new ideas, although it is sufficiently nontechnical for the interested layman. It is not appropriate for use as a textbook, nor was it intended for such use, but it may well be valuable to students of research methodology. This is particularly true of the chapter in which Bartlett attempts to reconstruct some of his own scientific thinking.

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The Lipids. Their chemistry and biochemistry. vol. III, *Biochemistry.* Biosynthesis, oxidation, metabolism, and nutritional value. Harry J. Deuel, Jr. Interscience, New York, 1957. xxxvi + 1065 pp. $25.

The text of this posthumous, third, and final volume of *The Lipids* was completed before the untimely death of Harry Deuel. Some of his colleagues and friends have finished the task of seeing the manuscript through the press. The material was left largely unchanged, except that certain minor corrections of details have been made to include some information that became available after the time of the author's final draft. A brief biographical introduction has been provided by his long-time friend George R. Cowgill.

Chapter 1 provides a recapitulation of what is known about digestion, absorption, transport, and storage of lipids —topics considered at length in volume 2.

Seven chapters deal with the metabolism, including, as possible mechanisms, the biosynthesis and oxidation of fats; fatty acids of various kinds, saturated and unsaturated, with straight and branched chains; hydroxy, keto, di- and tricarboxylic acids; fatty acid amides and aldehydes; phospholipids and their hydrolysis products; cholesterol and related sterols; and hydrocarbons. Other chapters review the role of acetic, formic, and propionic acids in the intermediary metabolism of fats; the question of the conversion of fat to carbohydrate; and the metabolism and nutritional value of the vitamins A, D, E, and K. The carotenoid pigments, the essential fatty acids, and the nutritional value of fats—subjects of long interest to Deuel, as attested by the many references to articles bearing his name—are especially fully treated.

The discussions are noteworthy for the comprehensive and detailed presentation of the historical background and development of the several topics and for the attention given to earlier theories and views, even though experimentally unconfirmed or subsequently discredited. In general, the compilation of knowledge of the various subjects has been based on a very thorough review of the literature, carried well up to date. Rapid advances in certain of the areas and the circumstances surrounding the completion of this volume have, however, precluded the inclusion of some more recent discoveries, such as the biosynthesis of lecithin and the oxidation of propionic acid and certain branched-chain fatty acids.

All who are interested in the chemistry and biochemistry of the lipids are indebted to Deuel for the competence, industry, and tenacity of purpose with which he assembled and completed this three-volume treatise.

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The Tissues of the Body. An introduction to the study of anatomy. W. E. Le Gros Clark. Oxford University Press, New York, ed. 4, 1958. xii + 415 pp. Illus. $9.75.

This unique book first appeared in 1939. Dynamic in point of view and lucid in style, it was and remains entirely modern in presenting anatomy as a living science that can be studied by an experimental approach, rather than as simply a discipline limited to the study of embalmed cadavers and fixed tissues.

Human anatomy has traditionally been taught as two separate courses—gross anatomy and microscopic anatomy. Whether or not this is desirable lies outside the scope of this review. In any event, this arrangement is likely to persist in most medical schools, if only for convenience of presentation. Yet, whatever its virtues, it unfortunately tends to mislead the beginning student into regarding gross anatomy and microscopic anatomy as distinct and even unrelated disciplines. One of the great-

est virtues of this book is that it serves to link together these two approaches to anatomy and to demonstrate, in a manner which will appeal to even the beginning student, that they are properly parts of one and the same subject. Sir Wilfrid has, moreover, attained his goal of being not only informative but also intellectually stimulating.

In preparing this latest revision, the author has successfully resisted the too often fatal temptation to expand the contents; thus, despite the advances in anatomical knowledge, the book is only 43 pages longer than the first edition of 19 years ago. Unfortunately, some of the illustrations have deteriorated in the course of the several editions, and the type of paper used in this new one is not the most favorable one for halftones. One of the outstanding features of this book has been the numerous references, in the form of footnotes, to the pertinent, basic literature, a procedure that is particularly attractive to the medical student. The number of references (not allowing for some repetition) now totals nearly 600, and some 70 (or about 12 percent) relate to publications which have appeared since 1952, the date of the last previous edition.

In view of the growing tendency toward drastic curtailment of the time allotted to the study of human anatomy, at least in the United States, this up-to-date, integrating, and synthesizing presentation is especially valuable.

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Johns Hopkins University

New Books

Abstracts of Reports of the Fourth Soviet Conference on Electrochemistry. Academy of Sciences U.S.S.R. Press, Moscow, 1956. In English translation. Consultants Bureau, New York, 1958. 89 pp. $12.

Advances in Geophysics. vol. 5. H. E. Landsberg and J. Van Mieghem, Eds. Academic Press, New York, 1958. The contents of this volume are: "From polar years to IGY," N. C. Gerson; "Microseisms," B. Gutenberg; "The size and shape of the earth," R. A. Hirvonen; "Oceanic tides," A. T. Doodson; "Ultraviolet absorption process in the upper atmosphere," K. Watanabe; "The physics of cloud modification," James E. McDonald.

Annual Review of Physical Chemistry. vol. 9. H. Eyring, Ed. C. J. Christensen and H. S. Johnston, Associate Eds. Annual Reviews, Palo Alto, Calif., 1958. 519 pp. $7. The contents of this volume are: "Thermochemistry and thermodynamic properties of substances," M. A. Paul; "Cryogenics," H. A. Fairbanks *et al.*; "Solutions of electrolytes," T. Shedlovsky; "Solutions of nonelectrolytes," J. S. Rowlinson; "The solid state," L. Guttman; "Nuclear and electron spin resonance," J. E. Wertz); "Radiation chemistry," M. Lefort; "Ion exchange resins and membranes," W. J. Argersinger, Jr.; "Mechanical properties of high polymers," H. Leaderman; "Reaction kinetics and mechanisms of gas phase reactions," D. Garvin; Reaction kinetics in solution," A. Fava; "Quantum theory of electronic structure of molecules," M. Kotani *et al.*; "Surface chemistry and contact catalysis," A. G. Oblad and A. Farkas; "Physical organic chemistry," R. W. Taft *et al.*; "Molecular electronic spectra," G. Herzberg; "Spectroscopy," M. K. Wilson and V. A. Crawford; "Experimental molecular structure," D. P. Stevenson and J. A. Ibers; "Statistical mechanics," C. F. Curtiss; "High pressure developments," H. T. Hall and S. S. Kistler; "Optical rotary power," W. Kuhn; "Colloid and surface chemistry," A. C. Zettlemoyer.

An Atlas of Esophageal Motility in Health and Disease. Charles F. Code, Brian Creamer, Jerry F. Schlegel, Arthur M. Olsen, F. Edmund Donoghue, Howard A. Andersen. Thomas, Springfield, Ill., 1958. 143 pp. $8.50.

Automatic Measurement of Quality in Process Plants. Proceedings of a conference held at Swansea, 23–26 September 1957, by the Society of Instrument Technology. Academic Press, New York; Butterworths, London, 1958. 331 pp. $9.50.

Bailey's Textbook of Histology. Wilfred M. Copenhaver and Dorothy D. Johnson, Eds. Williams & Wilkins, Baltimore, Md., ed. 14, 1958. 646 pp. $11.

Basic Ecology. Ralph Buchsbaum and Mildred Buchsbaum. Boxwood Press, Pittsburgh, Pa., 1958. 200 pp.

Behavior and Evolution. Anne Roe and George Gaylord Simpson. Yale University Press, New Haven, Conn., 1958. 565 pp. $10.

Child-Centered Group Guidance of Parents. S. R. Salvson. International Universities Press, New York, 1958. 343 pp. $5.

Contributions in Geophysics. In honor of Beno Gutenberg. Hugo Benioff, Maurice Ewing, Benjamin F. Howell, Jr., Frank Press, Eds. Pergamon Press, New York and London, 1958. 252 pp. $9. The 17 papers in this volume were assembled to honor Beno Gutenberg when he retired as Director of the Seismological Laboratory of California Institute of Technology. Contributors include Markus Bath (Sweden), Perry Byerly and John DeNoyer (U.S.), Robert Stoneley (England), Pietro Caloi (Italy), Wilhelm Hiller (Germany), John H. Hodgson (Canada), Chuji Tsuboi (Japan), K. E. Bullen (Australia), I. Lehmann, (Denmark), J. P. Rothe (France), Howard E. Tatel and Merle A. Tuve (U.S.), Francis Birch (U.S.), C. L. Pekeris and H. Jarosch (Israel), F. A. Vening Meinesz (Netherlands), W. A. Heiskanen and U. A. Uotila (U.S.), H. E. Landsberg (U.S.), Walter Elsasser and Walter Munk (U.S.).

Current Concepts of Positive Mental Health. Joint Commission on Mental Illness and Health, Monogr. Ser. No. 1. Marie Jahoda. Basic Books, New York, 1958. 136 pp. $2.75.

The Development of the Verbal Categories in Child Language. Publ. 9 of Indiana Univ. Research Center in Anthropology, Folklore, and Linguistics. Henry and Renee Kahane and Sol Saporta. Research Center, Indiana Univ., Bloomington, 1958. 65 pp. $2.50.

Disinfection and Sterilization. G. Sykes. Van Nostrand, Princeton, N.J., 1958. 414 pp. $10.75.

The Doctor Business. Richard Carter. Doubleday, Garden City, N.Y., 1958. 283 pp. $4.

Economics of Mental Illness. Joint Commission on Mental Illness and Health, Monogr. Ser. No. 2. Rashi Fein. Basic Books, New York, 1958. 184 pp. $3.

A Grain of Mustard Seed. Alice Albertson Shurrocks. Reynolds-DeWalt, New Bedford, Mass., 1958. 245 pp. This is described as a sequel to *Nantucket Wildflowers* (Putnam's, New York, 1921).

Electroanalytical Chemistry. James J. Kingane. Interscience, New York, ed. 2, 1958. 683 pp. $14.50.

Hot Laboratory Equipment. L. G. Stang, Jr. U.S. Atomic Energy Commission, Washington, D.C., ed. 2, 1958 (order from Supt. of Documents, GPO, Washington 25). 429 pp. $2.50. This book gives detailed descriptions and design data for facilities, equipment, and accessories used in handling moderate to large amounts of radioactive materials. It is an enlarged and revised version of pt. II of *Chemical Processing and Equipment* (TID-5276), published in 1955. The earlier work contained 126 items; this revision contains 229 items.

The Indian Zoological Memoirs on Indian Animal Types. pt. 6. Palaemon (The Indian river prawn). S. S. Patwardhan. Zoological Soc. of India, c/o Zoological Survey of India, Calcutta, ed. 2, 1958. 122 pp. Rs. 5.

Insecticide Resistance in Arthropods. Monogr. Ser. No. 38. A. W. A. Brown. World Health Organization, Geneva, 1958 (order from Columbia Univ. Press, New York). 234 pp. $5.

Introduction to Modern Physics. C. H. Blanchard, C. R. Burnett, R. G. Stoner, R. L. Weber. Prentice-Hall, Englewood Cliffs, N.J., 1958. 425 pp. $10.

Perspectives in Marine Biology. A symposium held at Scripps Institution of Oceanography, University of California, 24 March–2 April 1956. A. A. Buzzati-Traverso, Ed. Univ. of California Press, Berkeley, 1958. 637 pp. $10. The papers presented at this symposium—conducted under the auspices of the International Union of Biological Sciences and sponsored jointly by the Office of Naval Research and Scripps Institution of Oceanography—are divided into the following parts: ecology, physiology and biochemistry, behavior, and genetics and evolution. The symposium was attended by 183 participants from Austria, Brazil, Canada, Denmark, England, Finland, France, Germany, Hawaii, Italy, Japan, Mexico, Puerto Rico, Scotland, Spain, Sweden, and the United States.

Reports

Action of Lipid-Soluble Quaternary Ammonium Ions on Conducting Membranes

Bioelectric currents which propagate the nerve impulse are carried by ions. The membrane theory, proposed at the turn of the century and which, with small modifications, is still the basis of most modern concepts, assumes that a change in ion permeability of the conducting membrane is responsible for the currents. Such a change was experimentally demonstrated by Cole and Curtis (*1*). Fundamental for the understanding of the process is the question: What is the mechanism by which this permeability change is produced? How does the potential source of electromotive force, the ionic concentration gradients between inside and outside, become suddenly effective? Two opposing views confront each other: (i) Conduction is a purely physical process (*2*), and (ii) chemical reactions change the membrane permeability and control the ion movements (*3*).

Recently, A. V. Hill and his associates have shown, with very fast recording instruments and *Maja* nerve at 0°C, that the previously recorded small initial heat production consists of two distinct phases: a rather large positive heat, roughly coinciding with the electrical activity, followed by a negative heat taking place within 100 to 300 msec after the active phase (*4*). The data lend strong support to the assumption that chemical reactions underlie the activity. This is also supported by the high Q_{10} of the action potential. With the isolated single electroplax of *Electrophorus electricus*, Schoffeniels (*5*) found a Q_{10} of 3.6; the activation energy is 21,000 cal/mole. The results of these physical recordings thus favor the assumption of chemical reactions.

The necessity of chemical processes was maintained by Nachmansohn and his colleagues. They proposed 15 years ago that the action of acetylcholine is essential for the permeability change in conduction. This view is based on the various physiological and biochemical features of the acetylcholine system present in all conducting tissue throughout the animal kingdom. The system has the prerequisites required to generate bioelectric currents: It has the necessary speed, it is inseparable from conduction, it precedes in the sequence of energy transformations all other reactions, and its association with electrical events has been demonstrated in a variety of ways. Nachmansohn's view was nevertheless opposed essentially because of the failure of acetylcholine to affect conduction when applied externally. This lack of effect was explained by the failure of acetylcholine to reach the active sites since it could be experimentally demonstrated that acetylcholine does not penetrate to the inside of the cell (*6*).

A new development started with the preparation of lipid-soluble quaternary ammonium ions, analogs of acetylcholine. The first such compound was pyridine aldoxime dodecyliodide (PAD), a lipid-soluble analog of pyridine aldoxime methyliodide (PAM) (*7*). This latter structure was designed by Wilson on the basis of molecular complementariness and proved to be a powerful antidote against nerve gas (*8*). This and several other lipid-soluble quaternary ammonium ions block in low concentrations conduction of crab and lobster axons. They depolarize the electroplax of *Electrophorus electricus*. In the first records obtained with these cells the polarity was even reversed (overshoot) (*9*), but this could not be reproduced. When they are applied to muscle, the lipid-soluble quaternary ammonium ions produce contraction which can be repeated many times even when the myoneural junction is completely blocked by curare (*10*). Thus, the biological action must be attributed to a direct action of the acetylcholine analogs on the conducting membrane.

Recently, Staempfli tested one of these compounds, noracetylcholine 12 (in which one methyl on the N of acetylcholine is replaced by a dodecyl group) on Ranvier nodes of frog nerve (personal communication). In $10^{-3}M$ concentration, the compound produced a complete and irreversible depolarization of the membrane. In $10^{-4}M$ concentration, a reversible depolarization was obtained. In concentrations of $3 \times 10^{-5}M$, the compound increased the amplitude and duration of the action potential. The effects on the membrane take place within seconds. This is a high speed, only slightly less rapid than that observed with K^+. Similar and even slightly more potent effects on the conducting membrane of the desheathed frog tibialis nerve were obtained by Dettbarn with PAD (*11*). For the interpretation of the effects, the question is crucial whether or not they are produced by a specific action upon the acetylcholine receptor postulated to be the physiological cell constituent whose reaction with acetylcholine is essential for the permeability change; if it were possible to demonstrate directly that this is really the basis for the depolarizing action of the lipid-soluble quaternary ammonium ions, that the modified molecule has the intrinsic ability to react with the receptor and to affect the change normally effected by acetylcholine, this would be new and conclusive evidence.

Evidence in this direction has now been obtained (*12*). If PAD depolarizes the membrane by reacting with the acetylcholine receptor—that is, if it is a receptor activator—a receptor inhibitor should by competitive action protect the active surface of the protein against the quaternary ammonium ion. This is indeed the case. Eserine, as is well known, has a high affinity for the acetylcholine system. It is a potent cholinesterase inhibitor; it is also a receptor inhibitor. When eserine is added to the desheathed frog tibialis nerve in $7 \times 10^{-3}M$ concentration, addition of a markedly depolarizing concentration of PAD has no effect. Lower concentrations of eserine strongly counteract the effect of PAD but do not abolish it. Higher concentrations of PAD may overcome the protective action of eserine. The antagonism between the two compounds is thus typical for competitive action. A description of the details is in preparation (*11*).

The fact that these lipid-soluble analogs of acetylcholine have a fast and reversible depolarizing action on nerve in concentrations of a few micrograms per milliliter and produce muscular contraction outside the myoneural junction as postulated by theory, and the evidence

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Instructions for preparing reports. Begin the report with an abstract of from 45 to 55 words. The abstract should *not* repeat phrases employed in the title. It should work with the title to give the reader a summary of the results presented in the report proper. (Since this requirement has only recently gone into effect, not all reports that are now being published as yet observe it.)

Type manuscripts double-spaced and submit one ribbon copy and one carbon copy.

Limit the report proper to the equivalent of 1200 words. This space includes that occupied by illustrative material as well as by the references and notes.

Limit illustrative material to *one* 2-column figure (that is, a figure whose width equals two columns of text) or to *one* 2-column table or to *two* 1-column illustrations, which may consist of two figures or two tables or one of each.

For further details see "Suggestions to Contributors" [*Science* **125**, 16 (1957)].

that they act specifically on the acetylcholine receptor, are new supports for the proposed role of acetylcholine in conduction, especially when considered in connection with the huge amount of physical and chemical data accumulated in the last two decades in favor of this concept.

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An Immunological Investigation of Human Pituitary Growth Hormone

Abstract. Growth hormone isolated from human pituitaries has been demonstrated to be a good antigen in the rabbit. With the rabbit antiserum to human somatotropin, it is possible to detect as little as 0.1 μg of the hormone by precipitin test. The antiserum was also capable of neutralizing the growth-promoting activity of human somatotropin.

It is the purpose of this report to present evidence for the antigenicity of human pituitary growth hormone (somatotropin) in rabbits and guinea pigs. Although Cruickshank and Currie have recently produced antisera to pituitary somatotropin from humans (*1*), they were unable to demonstrate by means of precipitin tests the presence of any antibodies that were hormone-specific. Absorption of the somatotropin antiserum with their human ACTH or TSH preparations resulted in the loss of antibodies to somatotropin itself. Heijkenskӧld and Gemzell (*2*) did not detect any precipitating antibodies to human somatotropin in the sera of rabbits, guinea pigs, and rats that had been injected with the hormone.

The production of a potent antiserum to highly purified bovine pituitary growth hormone has recently been reported (*3*). This antiserum, freed of certain nonspecific antibodies by absorption, was found to be capable of detecting as little as 0.5 to 1 μg of bovine somatotropin by the precipitin ring test, and it gave no cross reaction with comparable and considerably higher doses of all the other known anterior pituitary hormones. Furthermore, it was observed that relatively small amounts of the antiserum could completely neutralize the biological activity of the bovine somatotropin (*3*).

In the present investigation, highly purified human pituitary growth hormone prepared according to a method previously outlined (*4*), was employed for the sensitization of guinea pigs and the immunization of rabbits. Guinea pigs were readily sensitized to the human somatotropin preparation. A dose of 10 μg of the hormone suspended in 0.4 ml of the adjuvant Bayol-Arlacel (*5*) was injected subcutaneously; the same dose was repeated 3 days later. Three weeks after the initial sensitizing dose, the animals were challenged intracardially with varying doses (0.025 to 0.100 mg) of the hormone in 0.5 ml of saline solution. Eight out of 11 of these animals showed typical signs of severe anaphylactic shock and succumbed within 3 to 5 minutes after the injection, whereas no signs of anaphylaxis following similar doses of somatotropin were demonstrable in six control animals that had undergone no prior sensitization.

The antiserum was prepared in the following matter. Young albino female rabbits, weighing approximately 2.6 to 2.8 kg each, were injected with a total of 4 mg of somatotropin suspended in Freund's adjuvant according to the procedure of Cohn (*5*); of this dose, 2 mg was administered subcutaneously and 2 mg intraperitoneally. Two weeks later the rabbits were bled from the marginal ear vein and were injected the following day with 4 mg of somatotropin in the same manner as before. After another interval of 2 weeks, the animals were each injected with 2 mg of the hormone, 1 mg subcutaneously and 1 mg intraperitoneally, in the alum precipitate form (*6*), bringing the total dose of somatotropin per rabbit to 10.0 mg. The rabbits were bled by cardiac puncture 10 days later, and the serum was frozen and stored until use.

Precipitin ring tests (*6*) were performed with the rabbit antiserum to determine the smallest amount of human somatotropin that could be detected. Tubes were set up containing a serial dilution of antigen ranging from 0.5 down to 0.00005 mg in 0.5 ml of saline. One-tenth milliliter of human somatotropin antiserum from which certain nonspecific antibodies had been removed by absorption was carefully layered under the antigen phase. Tests were read after incubation for 1 hour at 30°C. The minimal amount of somatotropin giving a definite positive precipitin test was 0.1 μg of the hormone.

The antiserum was also tested to determine whether or not it was capable of neutralizing the biological activity of the human somatotropin, as determined by bioassay according to the standard 4-day tibia test in hypophysectomized rats (*7*). The experimental animals, all hypophysectomized, were apportioned into three groups. The first group, consisting of six animals, served as controls and received normal rabbit serum only. The five animals in group 2 were injected with normal rabbit serum plus somatotropin, and the six animals in group 3 received antiserum and somatotropin. The daily dose of hormone was 0.010 mg in 0.5 ml of saline solution, injected subcutaneously, and the daily dose of serum was 0.25 ml, administered intraperitoneally. The injections of serum were begun 4 hours prior to the first injection of hormone, so that over the 4-day injection period, five injections of serum were administered. The animals were sacrificed approximately 24 hours after the final injection of hormone. The results showed that the total dose of 0.040 mg of somatotropin had increased the width of the tibial epiphyseal cartilage plate to 237 ± 4 μ (mean ± standard error), as compared with 160 ± 1 μ for the controls that had received normal rabbit serum only. The simultaneous administration of antiserum with the somatotropin had resulted in a complete neutralization of the hormonal effect (164 ± 3 μ). It has previously been demonstrated (*3*) that the injection of bovine somatotropin antiserum alone does not have any significant influence upon the width of the tibial epiphyseal cartilage plate in the hypophysectomized rat (157 ± 4 μ, as compared with 161 ± 3 μ for the uninjected hypohysectomized controls). The fact that the biological activity of somatotropin was neutralized completely when the hormone and relatively small amounts of the antiserum were injected into two entirely distinct sites by two different routes in the same animal suggests the specificity of the antigen-antibody reaction in question. The findings from the precipitin tests, supported by the results of the antihormone tests, have further suggested that an immunological method of assay for the presence of

pituitary growth hormone in biological fluids may be possible.

It was of interest to note in a separate experiment that although antiserum to *bovine* somatotropin was capable of neutralizing the activity of somatotropin from the same species, confirming our previous findings (*3*), it was incapable of altering the activity of *human* somatotropin in the hypophysectomized rat. The species specificity of somatotropin antibodies was thus clearly demonstrated in this instance. A comparative serological study of pituitary somatotropin from various species is in progress (*8*).

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Tranquilizing and Antiserotonin Activity of Nicotinamide

Abstract. Nicotinamide in large amounts antagonized the action of serotonin on smooth muscles in vitro and in vivo. It also tranquilized animals. The antagonism differed in some respects from that of an antimetabolite of serotonin.

Two recent events have suggested that nicotinamide might act as an antagonist to the hormone serotonin. These are (i) the suggestion by Woolley and Shaw (*1*) that the cerebral serotonin content plays a role in mental disorders such as schizophrenia, and (ii) the claim of Hoffer *et al.* (*2*) that massive doses of nicotinamide or nicotinic acid control most cases of schizophrenia.

Woolley and Shaw pointed out that a variety of chemical compounds which they had shown to be antimetabolites of serotonin were able to call forth in normal men and animals some of the signs characteristic of mental disturbances and suggested that this was to be interpreted to mean that the naturally occurring mental disorders of similar type probably arose from an abnormality in serotonin in the brain. Some evidence was found to indicate that the difficulty was a deficiency of cerebral serotonin, but other findings suggested that instead an excess of this hormone might be involved (*3*, *4*). It has not yet been possible to decide between these two alternatives. When Hoffer *et al.* announced that large amounts of nicotinamide controlled the disease, the idea occurred to us that if nicotinamide could be shown to act as an antagonist to serotonin this fact would argue in favor of the "too much" alternative.

In isolated smooth muscles and also in whole animals nicotinamide has now been found to act as an antagonist to serotonin. The isolated uterus from estrogenized rats is known to be a suitable test object with which to demonstrate antiserotonin activity (*5*). The muscle was standardized with serotonin, as previously described (*6*). Nicotinamide was applied and the response to serotonin was again measured. Usually nicotinamide caused half maximal inhibition of the contraction when it was present in a final concentration of 0.002*M*, and complete inhibition at 0.01*M* (eight experiments). An occasional tissue required more, but the most needed was 0.01*M* for half, and 0.02*M* for complete, inhibition.

These were the amounts needed to counteract an amount of serotonin just sufficient to elicit a maximal contraction in the untreated muscle. When the dose of serotonin was increased, the amount of nicotinamide required to counteract it was also increased, but not proportionately—that is, the antagonism was not strictly competitive. Once a uterus which had been very sensitive to serotonin (for example, maximal contraction to 0.003 μg/ml) had been treated with an inhibitory amount of nicotinamide, washing would not restore the sensitivity. Such a tissue would, however, respond to larger amounts of the hormone (0.02 μg/ml). The effect of the inhibitor then could be washed away readily, so that the washed tissue would again respond to 0.02 μg. There was thus only loss of the original sensitivity to the hormone, but the newly established level of response could be regained after removal of the nicotinamide.

The specificity of nicotinamide as an antagonist to serotonin was examined by determination of whether it also would counteract the action of acetylcholine on the same muscle. An amount of nicotinamide which would inhibit the serotonin response almost totally reduced only slightly the acetylcholine response (see Table 1). However, larger amounts of nicotinamide did prevent acetylcholine-induced contractions. Washing of the tissue restored the ability to contract to acetylcholine or to serotonin, so that no irreversible damage had been done to the muscle. Nicotinamide was thus not a specific antagonist to serotonin, but in the uterus the antiserotonin action was more prominent than the acetylcholine antagonism.

Table 1. Contractions of an isolated rat uterus caused by serotonin or acetylcholine in the presence and absence of nicotinamide.

Serotonin (μg/ml)	Acetylcholine (μg/ml)	Nicotinamide (*M*)	Contractions (cm)
0.01	0	0	5.5
0	0.04	0	4.0
0.01	0	0.003	0.5
0	0.04	0.003	3.0

Sodium nicotinate did not show any antagonism to serotonin in this tissue, even at 0.1*M* concentration. All solutions were of course adjusted to physiological *p*H in order to avoid the inhibition caused by acidity.

The antiserotonin activity of nicotinamide in living animals was shown in mice treated with 5-hydroxytryptophan according to a method recently described for the evaluation of antimetabolites of serotonin (*7*). This is a severe test of a compound, but 43 mg of nicotinamide gave 50 percent protection against 1 mg of hydroxytryptophan. When the test was made slightly less severe by reduction of the hydroxytryptophan to 0.4 mg per mouse, a complete protection of all mice was observed with 25 mg of nicotinamide.

One prominent feature seen in mice given these massive amounts of nicotinamide was marked lethargy or tranquilization. This was more severe than that seen in mice given reserpine. If lethargy is a feature of antiserotonins which reach the brain (*4*) (reserpine, chlorpromazine, certain synthetic antimetabolites of serotonin) then this effect of nicotinamide is noteworthy in understanding the relationship of serotonin to the mind.

One wonders about the mechanism of the antiserotonin action. Nicotinamide is

Table 2. Antagonism of uterine contraction by various antiserotonins.

Serotonin (μg/ml)	$CaCl_2$ (μg/ml)	Nicotinamide (*M*)	BAS* (μg/ml)	Contractions (cm)
0.01	0	0	0	4.1
0	200	0	0	4.3
0.01	0	0.02	0	0
0	200	0.02	0	0.5
0.01	0	0	1	1.0
0	200	0	1	4.5

* 1-benzyl-2,5-dimethyl serotonin hydrochloride.

not a structural analog of serotonin. This, and the lack of competitive antagonism, would argue against its being an antimetabolite of the hormone. Present data indicate that the action is indirect. Thus, nicotinamide was found to inhibit the muscle-contracting action of Ca^{++}, whereas a specific antimetabolite of serotonin, BAS (*8*), did not (see Table 2). If the action of serotonin on muscle and nerve cells is to transport Ca^{++} into them (*6, 9*), then a specific antiserotonin should not interfere with the serotonin-like action of Ca^{++}. Conversely, an agent which did not antagonize directly the basic action of serotonin, but which interfered with some other steps of the contractile process of muscle (for example, the energy-yielding ones), should also interfere with the action of Ca^{++}. This is what nicotinamide was found to do. Such indirect inhibitions might be of DPNase or the transmethylation processes which are known to be sensitive to nicotinamide. Elucidation of the precise mechanism must await further study.

The main purposes of this note (*10*) are to point out that nicotinamide affects the behavior of normal animals and that its effects are not incompatible with its ability to act as an antagonist to serotonin and to acetylcholine.

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Researches on the Mechanism of Reserpine Sedative Action

In recent years experimental evidence has accumulated on the possibility that reserpine acts as a sedative through release of serotonin (*1*). Such a hypothesis has been suggested and supported by Brodie *et al.*, who have shown (i) that release of serotonin takes place only with *Rauwolfia* alkaloids which have sedative action (*2*); (ii) that central antagonists of serotonin, such as lysergic acid diethylamide (LSD) (*3*), are also antagonists of reserpine (*4*); and (iii) that substances which increase brain serotonin, such as iproniazid, can reverse the sedative activity of reserpine (*4, 5*).

Recently Lessin and Parkes (*6*) stressed the importance of hypothermia occurring after administration of reserpine as an explanation of its sedative activity. But serotonin too can decrease body temperature (*7*). This observation may explain the potentiation of barbiturates by serotonin, since the hypnotic effects of barbiturates are increased when hypothermia is induced (*8, 9*). Finally, in Pletscher's experiments, iproniazid antagonized both serotonin metabolism and hypothermia after reserpine (*10*).

These data prompted us to determine whether a relationship between the sedative action of reserpine, serotonin release, and hypothermia is evident under different experimental conditions.

The sedative action of reserpine was evaluated by the potentiation of sleeping-time after administration of pentobarbital (20 mg/kg, intraperitoneally). Brain serotonin was extracted according to the method of Bogdanski *et al.* (*11*) and measured spectrophotometrically at 275 mμ by the method of Udenfriend *et al.* (*12*). Rectal temperature was determined with a resistance thermometer. The experiments were carried out with 200-g female albino rats kept in constant-temperature rooms at 0°, 22°, 29°, or 37°C and injected intraperitoneally with 2.5 mg of reserpine per kilogram 4 hours before the reported determinations. The results are summarized in Table 1.

Table 1. Results. The figures in parentheses show the number of animals in each series. Each brain serotonin value represents an analysis of the pooled brains of two to three animals.

Treatment	Room temperature (°C)	Time (hr)	Rectal temperature (°C ± S.E.)	Brain serotonin (μg/g ± S.E.)	Sleeping-time after pentobarbital ± S.E.*	Animals that went to sleep/ treated animals
Control	0	21	36.6 ± 0.15 (10)	0.93 ± 0.11 (6)		
Reserpine	0	21	34.3 ± 0.26† (10)	0.99 ± 0.024 (10)		
Control	22	21	37.3 ± 0.09 (25)	0.91 ± 0.05 (30)	25′ ± 1′37″	11/22
Reserpine	22	21	32.6 ± 0.3† (15)	0.26 ± 0.02† (8)	53′ ± 2′13″†	20/22
Control	29	4	37.3 ± 0.4 (5)	0.96 ± 0.03 (4)	24′ ± 1′41″	6/8
Reserpine	29	4	34.4 ± 0.3† (5)	0.29 ± 0.037† (4)	63′ ± 1′45″†	7/8
Control	29	21	37.2 ± 0.18 (5)	1.02 ± 0.034 (4)	24′ ± 1′52″	5/8
Reserpine	29	21	34.5 ± 0.19† (5)	0.31 ± 0.035† (4)	54′ ± 3′35″†	7/8
Control	37	4	37.5 ± 0.14 (5)	1.15 ± 0.04 (4)	23′ ± 2′20″	6/8
Reserpine	37	4	37.2 ± 0.13 (5)	0.85 ± 0.35 (4)	28′ ± 1′14″	5/8
Control	37	21	37.1 ± 0.1 (15)	1.25 ± 0.074 (6)	24′ ± 1′04″	8/16
Reserpine	37	21	37.0 ± 0.12 (15)	1.72 ± 0.24† (10)	24′ ± 1′24″	7/16

* The average includes only the number of animals that went to sleep after receiving pentobarbital.
† Significant beyond the 0.01-level of probability.

Our results show that increasing room temperature from 22° to 37°C does not change body temperature and sleeping-time after pentobarbital but does induce a small increase in the content of brain serotonin. After reserpine is injected, sedation is present only if serotonin is released and body temperature decreases (22° and 29°C). At 37°C, body temperature is unchanged and brain serotonin increases after administration of reserpine; under these conditions there is no evidence of sedative activity. At 0°C reserpine significantly decreases body temperature, with no change in brain serotonin. The measurement of sleeping-time after pentobarbital was very difficult to evaluate because the cold provokes large variations between animals. However, when the rats which had been at 0°C were brought to normal room temperature, it was evident that animals treated with reserpine did not show typical sedation and ptosis. But after 1 to 2 hours at normal temperature sedation appears. An experiment, carried out by keeping the animals after reserpine treatment for 4 hours at 0°C and for 4 hours at 22°C, showed in fact a decrease of brain serotonin (0.63 ± 0.08 μg/g).

Thus, at 22°, 29° and 37°C, there is a parallelism between the onset of the sedative activity of reserpine, as indicated by an increase of barbiturate narcosis, serotonin release, and hypothermia. In contrast, at 0°C we obtained hypothermia after reserpine injection, without sedative activity or serotonin release. It is not simply a delayed action, for 8 hours after reserpine treatment at 0°C we observed no decrease in the content of brain serotonin (1.17 ± 0.06 μg/g).

Our results agree with the hypothesis that the sedative action of reserpine takes place only when there is serotonin release. The onset of hypothermia is not always associated with sedation, and it is not correlated with serotonin release. This is true also in experiments in which we kept the animals in ice bath until their rectal temperatures reached 30°C. Under these conditions no decrease of brain serotonin occurs (1.07 ± 0.1 μg/g).

It is interesting to speculate on the

reasons why reserpine does not exert sedative activity when room temperature is 37° or 0°C. We believe that the stress reaction with release of catecholamines takes place at 0° and at 37°C. In this regard recent experiments may be recalled in which DOPA, a precursor of noradrenaline, antagonizes the sedative activity of reserpine (*13*).

The increase of brain serotonin at 37°C may be considered as a situation analogous to that occurring after iproniazid administration, when reserpine does not show sedation (*14*).

Note added in proof. Since this communication was submitted for publication we checked our results with a more specific method for evaluation of brain serotonin [D. F. Bogdanski *et al.*, *J. Pharmacol. Exptl. Therap.* **117**, 82 (1956)]. Thus, using a spectrofluorimetrical technique, we confirmed that reserpinized rats kept at a room temperature of 37°C have a higher brain serotonin (0.36 ± 0.009 μg) than the animals treated with reserpine at a room temperature of 22°C (0.16 ± 0.008 μg).

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Demethylation of Chlorpromazine-(N-Methyl)-C^{14}

Abstract. Chlorpromazine methyl-C^{14} was administered to three groups of rats —orally to one group following chronic oral administration of the unlabeled drug; orally to an unprimed group; and intravenously to another unprimed group. Appearance of $C^{14}O_2$ in the air expired by all animals indicated that the rat metabolized the side chain of the labeled drug.

Previous studies on the metabolism of the psychopharmacologic (*1*) agents containing the phenothiazine nucleus have resulted in little information about the fate of the N-aliphatic side chain of this class of compounds. Berti and Cima (*2*) suggested that this side chain was unchanged in all of the urinary compounds examined in their study on the fate of chlorpromazine administered to rabbits. Salzman and Brodie (*3*) failed to detect any demethylation of chlorpromazine upon incubation of the drug with rabbit-liver homogenate, even though La Du *et al.* (*4*) showed an active demethylation system for drugs to be present in liver. As a part of our program concerned with the metabolism of phenothiazine compounds, we have studied the fate of the side chain of chlorpromazine by using chlorpromazine-(N-methyl)-C^{14}. This report describes the extensive in vivo demethylation of the drug manifested by the appearance of $C^{14}O_2$ in the air expired by the rat.

Chlorpromazine was labeled with carbon-14 by reacting 2-chloro-10-(methylaminopropyl)-phenothiazine with formaldehyde-C^{14} (*5*). The product was identified as 2-chloro-10-(dimethylaminopropyl)-phenothiazine hydrochloride by ultraviolet spectrum analysis (maximum, 255 mμ) and by paper chromatography in isoamyl alcohol, water, formic acid, and ethanol (100:100:10:15) and in isoamyl alcohol, *n*-butanol, ammonia, and water (8:8:1:3). Its specific activity, 2.42×10^6 count/min mg (3.05 μc/mg), was determined by oxidation to carbonate, according to the wet-persulfate procedure (*6*). The radioactivity was counted as $BaCO_3$ in a thin-window gas-flow counter to a statistical accuracy of 1 percent. All counts were corrected to samples of infinite thinness by reference to a standard self-absorption curve for $BaCO_3$.

Expiration of radioactive CO_2 was followed in groups of adult male rats of the Long Evans strain. One group of five animals was fasted overnight prior to the oral administration of 15 mg of chlorpromazine per kilogram (approximately 13.9×10^6 count/min kg) in 2 ml of distilled water, by stomach tube. In order to study the effect of chronic administration of the drug upon the metabolism of the rat, a second group of five rats was pretreated with 15 mg of chlorpromazine per kilogram *per os* daily for 10 days prior to fasting and the oral administration of the same amount of labeled chlorpromazine with an average activity of 11.9×10^6 count/min kg. The third group of three animals received 2 mg of chlorpromazine per kilogram (approximately 4.86×10^6 count/min kg) intravenously in 0.5 ml of physiological saline solution by injection into the tail vein. After administration of the labeled drug, the animals were maintained in an all-glass metabolism chamber, and the expired air was collected in sodium hydroxide solution. All animals were studied for 6 hours, and two rats from each that had received the drug orally were followed for 12 hours. Radioactivity was recovered from the absorptive solutions at hourly intervals as $BaCO_3$ and determined according to the procedure used for the radioactive drug.

Figure 1 shows the release of radioactivity by the three groups of animals. Each point represents the average of the amount of radioactive CO_2 released during the collection interval, expressed as a percentage of the radioactivity administered to the animals. In all instances the label was detected during the first hour after administration of the chloropromazine-C^{14}. The radioactivity expired by the animals that had received a single administration of chlorpromazine-C^{14} was significantly greater ($p = 0.01$) than that released by the primed animals. Somewhat less $C^{14}O_2$ was expired during this period by the animals given the drug intravenously. Subsequently the $C^{14}O_2$ released declined and was not significantly different for any group beyond the first hour after administration.

Release of the label was extensive, since during the 6-hour collection period the unprimed oral group expired 16.7 percent of the administered radioactivity as $C^{14}O_2$. This was significantly greater ($p = 0.05$) than the amount expired by the primed animals, which re-

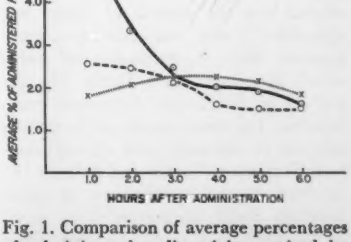

Fig. 1. Comparison of average percentages of administered radioactivity expired by rats following oral intravenous administration of chlorpromazine-(N-methyl)-C^{14} (see text).

leased 12.1 percent of the administered dose, or than that expired by the animals that received the drug intravenously; these released 12.3 percent of the administered dose as $C^{14}O_2$. A sustained release of radioactivity occurred, since the four animals maintained for 12 hours continued to expire from 0.7 to 2.0 percent of the dose each hour until the termination of the experiments.

These results show that the rat is capable of demethylating chlorpromazine-C^{14} and oxidizing the methyl group so that it appears as expired $C^{14}O_2$ following oral or intravenous administration of the drug. The tissues responsible for this transformation are the subject of current investigations.

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19 May 1958

Zinc Requirement for Growing Swine

Abstract. Swine fed rations containing 16, 21, 26, 31, 36, 41, or 46 parts per million of zinc gained 0.06, 0.13, 0.25, 0.52, 0.61, 0.69, and 0.76 lb, respectively, per day. Feed required per unit of gain decreased with each increment of zinc. Parakeratosis occurred in pigs fed 16, 21, 26, 31, or 36 ppm of zinc.

It has been shown by Bertrand and Bhattacherjee (*1*) and by Elvehjem and his associates (*2*) that zinc is a necessary constituent of the diet for the normal growth of mice and rats. O'dell *et al.* (*3*) and Roberson *et al.* (*4*) demonstrated that the growth of chicks was stimulated if zinc was added to a semipurified diet. A dermatitis of swine which Kernkamp and Ferrin (*5*) described in detail and designated parakeratosis has been shown to be greatly affected by inorganic and organic compounds present. Tucker and Salmon (*6*) reported that the symptoms of parakeratosis could be prevented or cured by the addition of zinc to the diet. Their work also showed that an excess of calcium or phosphorus, or both, markedly increased the incidence and severity of the disease. Recently these results were confirmed by Lewis *et al.* (*7*), Leucke *et al.* (*8*), and Conrad and Beeson (*9*) for both natural and purified diets, different calcium and phosphorus levels, and both $ZnCO_3$ and ZnO as sources of supplemental zinc. Prevention or cure was effected by these workers with levels of supplemental zinc from 50 to 100 ppm of the ration.

In view of the previous work our experiment was designed to determine whether parakeratosis of swine was a true zinc deficiency and, if so, what quantitative level of zinc is required.

Forty-two Duroc pigs weaned at the age of 3 weeks were allotted into seven groups containing six animals each. The average initial weight was 11.0 lb, and the animals were allocated on the basis of live weight, litter number, and sex. One female and one barrow were placed in a 3.5- by 7-ft concrete-floored pen which had a wooden platform covering the front half of the floor. No bedding was used, and all feeders and waterers were lined with glass. The pigs had free access to the feed. Chlorinated tap water containing 0.2 ppm of zinc was treated with a Zeolite water softener before it was put in the glass-lined waterers. The basal ration consisted of Drackett C-1 protein, 25 percent; cerelose, 30.8 percent; starch, 30.8 percent; corn oil, 5 percent; celluflour, 3 percent, and all minerals and vitamins known to be required by swine. The basal ration contained 0.66 percent calcium, 0.47 percent phosphorus, and 16 ppm of zinc. U.S.P. grade zinc oxide was added to the basal ration to provide the following levels of total zinc for treatments 1 through 7, respectively: 16, 21, 26, 31, 36, 41, and 46 ppm of the ration.

The summary of results at 8 weeks, as given in Table 1, shows that the growth rate was stimulated by each increment of added zinc. Statistical treatment of these data showed that the increase was linear. The pigs on treatments of 36, 41, and 46 ppm of zinc were continued on the trial for two additional weeks; and the average daily growth rates for the 10 weeks were 0.70, 0.84, and 0.95 lb, respectively. The first noticeable difference in growth rate occurred in the pigs on the basal ration during the third week of experiment. On the 23rd day of the trial, lesions of the epidermis were noticed on the underline of one pig in treatment 1 (no added zinc). Within a few days several pigs in lots 1 and 2 showed similar lesions of the skin; the dermatitis became more severe and spread to all parts of the body surface as the experiment progressed. Lesions appeared in lots 3 and 4 during the sixth week and in two pigs in lot 5 during the eighth week. The severity of the parakeratosis was in inverse proportion to the zinc content of the ration. The lesions were very similar to those described by Kernkamp and Ferrin (*5*) and by Tucker and Salmon (*6*). In addition, loss of appetite, severe scours, and greasy skin accompanied the dermatitis. Two pigs on the basal ration died. Careful weekly examinations of all pigs failed to show any symptoms of parakeratosis in the pigs fed 41 or 46 ppm of zinc.

Table 1. Performance of pigs fed different levels of zinc.

Item	Eight-week summary						
	1	2	3	4	5	6	7
Added zinc*	0	5	10	15	20	25	30
Total zinc (ppm)	16	21	26	31	36	41	46
Av. final wt. (lb)	15.0	18.0	24.9	40.2	44.9	49.9	53.5
Av. daily gain (lb)	0.06	0.13	0.25	0.52	0.61	0.69	0.76
Av. daily feed (lb)	0.82	0.82	1.04	1.28	1.40	1.54	1.59
Feed per pound gain (lb)	13.9	6.5	4.1	2.4	2.3	2.2	2.1
Parakeratosis (pigs)	6	6	6	4	3	0	0
Deaths	2	0	0	0	0	0	0

* Added zinc was U.S.P. grade zinc oxide.

Feed required per pound of gain decreased with each increment of zinc. However, the greatest differences were between the four lowest levels (16, 21, 26, and 31 ppm).

Four pigs with parakeratosis showed marked improvement in appetite, growth rate, and appearance of skin when they were placed on the basal ration fortified with 50 ppm of zinc. Appetite was noticeably improved within 2 days. During the 4-week recovery period, the pigs grew from an average weight of 29.6 lb to an average of 60.4 lb; the average rate was 1.18 lb/day.

Under the conditions of this experiment, symptoms of parakeratosis did not appear in growing pigs fed 41 ppm of zinc. A further increase in zinc to 46 ppm improved the growth rate 14 percent, indicating that the optimum requirement for this element is at least 46 ppm of the total ration. In subsequent studies the availability of zinc in the ration should be considered (*10, 11*).

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10. We express our appreciation to Mr. Vernon R. Heaton of the Calcium Carbonate Company, Quincy, Ill., for the zinc and calcium analyses of the rations.
11. This report is journal paper No. 1302, Purdue University Agricultural Experiment Station.

23 June 1958

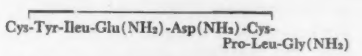
Inactivations of Oxytocin Suggesting Peptide Denaturation

Denaturation, a phenomenon associated with proteins (*1*), is frequently described by occurrences such as loss of biological activity, loss of crystallizability, change in solubility, increase in levorotation, and changes in parameters such as viscosity which indicate a change in the shape of the molecule. The term implies a subtle change in molecular structure, and the phenomenon, which is frequently base-catalyzed, is usually attributed to change in the configuration of the molecule due largely to a loss of hydrogen bonding, as is thought to occur with many proteins in concentrated solutions of urea. The role in the denaturation process in urea of sulfhydryl-disulfide interactions with resultant changes in cross-linking and molecular weight has also been recognized and has been studied for certain proteins (*2*).

Study of the inactivation of oxytocin, the cystine-containing octapeptide which is the chief oxytocic principle of the posterior pituitary, and of the material resulting from inactivation, suggests that denaturation, at least as defined by many of the criteria used with proteins, may occur with polypeptides of relatively small size. Two separate inactivations of oxytocin (molecular weight 1007) are described in this report (*3, 4*); both result in a large increase in levorotation.

Inactivation of oxytocin has been found to occur rather readily under the mildly alkaline conditions frequently used to form dinitrophenyl (–DNP) derivatives of peptides and proteins. A less soluble, higher molecular weight form of the hormone is obtained. This inactivation has been characterized as an intermolecular disulfide interchange. By treatment of the inactivation product with certain sulfhydryl reagents it has been found possible to regenerate the biological activity.

Mono-DNP-cystine (*5*), allowed to stand in 10.5 percent solution in the presence of five equivalents of $NaHCO_3$ at room temperature for 22 hours, was found to result in a mixture of approximately equimolar amounts of cystine, mono-DNP-cystine, and di-DNP-cystine (*6*), as indicated by paper chromatography. Oxytocin, represented by the structure (*7*)



is also, as are many proteins, an unsymmetrically substituted cystine derivative, or mixed disulfide. Under similar conditions, *p*H 8.3, a sample of the hormone with a potency of 350 unit/mg, as determined by the chicken depressor assay of Coon (*8*), gradually lost biological activity and deposited a white solid in 40 percent yield; $(\alpha)^{22.5}D$, –104° (*c*, 0.5; 1*N* acetic acid); compare $(\alpha)^{22.5}D$, – 23.1° for oxytocin acetate. Loss of activity was not inhibited under these conditions by the addition of N-ethyl maleimide and proceeded much more rapidly than in the absence of $NaHCO_3$. The rate of inactivation was markedly decreased at low hormone concentrations.

Analysis (*9*) of a hydrolyzate (6*N* HCl, 14 hours, 120°C) of the solid showed approximately the same composition as oxytocin. Probably due to its low solubility, the material remained at the origin on paper electrophoresis in sodium acetate buffer, *p*H 5.5, or sodium glycinate buffer, *p*H 9.5, or on paper chromatography with *n*-BuOH–H_2O–HAc (5:5:1), while oxytocin traveled 6.8 cm and 3.5 cm, $R_f = 0.3$, respectively. On electrophoresis in 5*N* acetic acid it moved toward the cathode somewhat faster than oxytocin. It rapidly deposited an amorphous flavianate in contrast to the slowly formed, more soluble crystalline flavianate characteristic of oxytocin (*10*).

Treatment of the inactivated material (7 unit/mg) (*11*) at a concentration of 0.15 mg/ml at *p*H 5.7 with 8 μmole/ml of the following reagents led after 3 days to the following biological activities in units per milligram: cysteine, 235 (*12*); glutathione, 150; H_2S (saturated solution), 200; homocysteine, 140; thioglycollic acid, < 9; thiomalic acid, < 6; ergothioneine, < 5; ovalbumin, < 3; ascorbic acid, 5; oxidized glutathione, 4. Sodium in NH_3 led to 22 unit/mg; $Na(NH_3)$ followed by cysteine, to 42. It was also found that similar treatment of oxytocin (480 unit/mg) with cysteine, H_2S, or thioglycollic acid (*13*) led to approximately the same potencies as were regenerated from the inactivated material (7 unit/mg) with each of these reagents, suggesting that the same equilibrium mixture is attained starting from either oxytocin or the inactivated oxy-

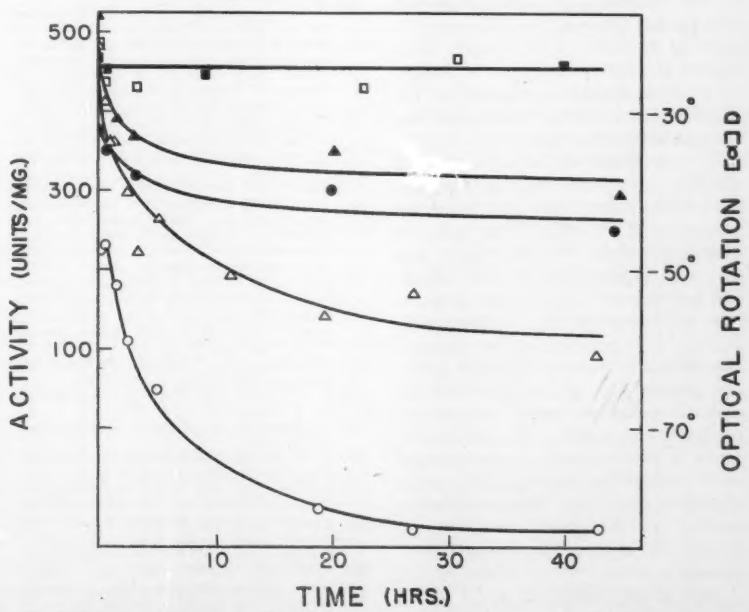


Fig. 1. Effect of urea on the biological activity and optical rotation (α)D of oxytocin, concentration 0.5 percent, at 22°C. Open circles, (α)D; open triangles, activity, 7*M* urea, *p*H 8. Solid circles, (α)D; solid triangles, activity, 7*M* urea, *p*H adjusted to 4.3 with acetic acid. Open squares, activity, 0.02*M* sodium barbital buffer, *p*H 8. Solid squares, activity, 0.02*M* sodium acetate buffer, *p*H 4.3.

tocin. The differences in the amount of activity regenerated from the inactivation product by the various —SH compounds may reflect differences in the reducing power of the —SH compounds and/or differences in the tendencies of the latter to form mixed disulfides with inactivated oxytocin (or oxytocin), as well as possible differences in the activity of the mixed disulfide species formed thereby. The unexpectedly low potencies obtained in the sodium-ammonia experiments indicate perhaps a greater lability, of undetermined type, toward the alkaline reagent than is the case with oxytocin or its S,S′-dibenzyl derivatives, which yield appreciable activity with this reagent (*14*).

A preliminary determination of molecular weight gave a calculated minimal value of 2250 (uncorrected for moisture) (*15*). The inactivated material is therefore a dimer or other higher molecular weight form of the hormone and may be represented at present as $(\text{oxytocin})_n$; $n \geqq 2$. The inactivation process would appear to involve cleavage of the intramolecular disulfide bond of oxytocin and the formation of intermolecular disulfide bonds between two or more molecules of the hormone. This inactivation of oxytocin, which may also be represented as an interchange between two or more molecules of an unsymmetrical disulfide, may be a prototype of some of the dimerization or aggregation reactions that occur with certain proteins, especially in concentrated solution. Whether it is related in mechanism to the interchange studied by several investigators between two different symmetrical disulfides (*6, 16*), which under neutral or alkaline conditions is thought to proceed through a reaction of the disulfide bond with a mercaptide ion, remains to be determined.

The occurrence of varying degrees of disulfide interchange during the handling of the posterior pituitary hormones may account for some of the losses in biological activity that take place, and may well explain some of the difficulties encountered in obtaining preparations of vasopressin of a uniform high potency. It is possible that the inactivation of these hormones in the body might also proceed through an intermolecular disulfide exchange, where it could be catalyzed enzymically. The inactivated forms of oxytocin and vasopressin could serve perhaps as physiological storage products for these hormones; when needed, activity could be generated through the action of body —SH compounds.

Because the conditions under which these hormones undergo molecular rearrangement with resultant increase in molecular weight are those which are useful for forming -DNP derivatives, it is apparent with cystine-containing peptides and proteins that structural interpretations based on data obtained through the dinitrophenylation procedure, and perhaps through other procedures as well, must be made with caution.

A second inactivation of oxytocin was observed when the polypeptide was allowed to stand in 7*M* urea solution. Changes in optical rotation were also followed (Fig. 1). The potency after 7 days at *p*H 8 was not increased by addition of cysteine to the solution, either before or after dialysis. The findings would suggest that secondary forces such as hydrogen bonding are of importance for biological activity in oxytocin. However, the possibility of chemical change should be ruled out before this inactivation in urea is ascribed to change in the spatial configuration of the oxytocin molecule.

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4. I express appreciation to Dr. V. du Vigneaud for the samples of arginine-vasopressin and some of the natural oxytocin, as well as for encouragement and stimulating discussion. Thanks are given to Mr. R. L. Tostevin and Miss D. W. Tull for the bioassays and to Mrs. L. S. Abrash for the chromatography on starch.
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13. The decrease in potency observed on treatment of oxytocin with H_2S is in substantial agreement with earlier observations using the guinea pig uterus [J. M. Gulland and S. S. Randall, *Biochem. J.* 29, 378 (1935)]. The results obtained with cysteine or thioglycollic acid are similar to those obtained by H. B. van Dyke, B. F. Chow, R. O. Greep, and A. Rothen [*J. Pharmacol. Exptl. Therap.* 74, 190 (1942)] with their protein-hormone complex. Under other conditions no change in potency was found on treatment of oxytocin with cysteine [R. R. Sealock and V. du Vigneaud, *ibid.* 54, 433 (1935)].
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18 June 1958

Airborne Immunization against Tuberculosis

Abstract. Inhalation of very small numbers of living attenuated (BCG) organisms and their multiplication in guinea pigs results in the development of acquired resistance against subsequent airborne infection with virulent tubercle bacilli. Different strains of BCG have differing capacities to immunize by this means.

It has long been known that certain attenuated mutant strains of tubercle bacilli are capable of limited, though definite, multiplication in animals susceptible to tuberculosis. The strain selected by Calmette and Guérin, BCG, for purposes of immunization, and some of its descendants, manifest this behavior. A wide variety of routes has been used to introduce such organisms into experimental animals or man (*1*), but introduction by the airborne route has not previously been investigated. During the course of such studies (*2*) we have observed that the viable units in certain cultures of BCG, even when inhaled in very small numbers, are able to "infect" and produce tuberculin allergy and immunity against subsequent airborne challenge with virulent tubercle bacilli in guinea pigs.

The apparatus and techniques employed were the same as those previously described (*3, 4*). Three different BCG strains have been used: a commercial BCG vaccine (*5*) prepared for purposes of immunization of human beings; and two different stock laboratory cultures of BCG, "D" and "T," derived from BCG 317, originally obtained from the Henry Phipps Institute (*6*). The "D" strain was maintained for long periods in the Deep-freeze and infrequently transferred in artificial media. The "T" strain had been frequently passed through Tween-albumin liquid medium for several years.

Suspensions of the commercially available BCG vaccine were prepared from glass vials of freeze-dried material: the

content of a vial (40 to 50 mg) was dispersed, as directed on the label, in 1 ml of sterile distilled water, and was shown by plate count to contain 2.5 (± 1) $\times 10^8$ viable units per milliliter. Such suspensions of BCG organisms, which contain many clumps of widely varying size, were further diluted in distilled water containing 0.1 percent serum albumin and 0.01 percent Tween 80 before introduction into the nebulizer for airborne infection.

Under the standardized conditions used, which involve a ½-hour exposure of guinea pigs in the airborne infection chamber, 10^3 viable units per milliliter of nebulizer fluid containing a *well-dispersed* suspension of fully pathogenic tubercle bacilli yield approximately one infecting unit per guinea pig (7).

In Table 1 are presented the results of exposing guinea pigs by the airborne route to various dilutions and, therefore, to various numbers of viable units of the untreated commercial BCG vaccine, and then challenging them with fully pathogenic tubercle bacilli by the same route. Statistical analysis has shown that the differences between the plate counts of virulent tubercle bacilli in the lungs and spleens of the unvaccinated tuberculin-negative animals and the groups of tuberculin-positive animals are highly significant ($p < .001$). Other typical manifestations of resistance were also seen in the tuberculin-positive animals: they had smaller numbers of grossly visible primary pulmonary lesions, smaller spleens, and smaller mediastinal lymph nodes than the controls. These gross observations were confirmed by microscopic examination of sections from the lungs and tracheobronchial nodes. Only a small proportion of the tubercles in the vaccinated animals had necrotic centers or contained acid-fast rods, whereas nearly all of the tubercles in the controls had necrotic centers and large numbers of stainable organisms. It is evident that four out of six guinea pigs estimated to have inhaled no more than 25 potentially infecting units (2.5×10^4 viable units per milliliter of nebulizer fluid) became hypersensitive to tuberculin and manifested a significant degree of acquired resistance to the subsequent airborne challenge.

In view of the poor degree of dispersion of the bacterial cells in the vaccine suspension used, it seems likely that a large proportion of the viable units and, therefore, of the droplet nuclei formed during nebulization, were too large to infect by inhalation (8). With better dispersion it can be anticipated that inhalation of fewer than 25 infective units per animal would be effective in conferring a significant degree of immunity on a majority of guinea pigs exposed under the same conditions.

It seems noteworthy that an increase of 100-fold in the number of viable units inhaled did not result in a further increase in immunity, although it did result in immunization of all of the animals. It is also important to state that the degree of acquired resistance manifested by airborne-BCG-immunized guinea pigs against subsequent virulent challenge is at least as great as guinea pigs show after immunization with many thousandfold larger numbers of viable BCG organisms by the subcutaneous route (4).

Table 1. Airborne BCG immunization of guinea pigs against experimental tuberculosis.

No. of animals	Airborne BCG exposure* (0 day)	Tuberculin reactions† (41st day)	Mean bacterial counts‡ after virulent challenge (70th day)	
			Lung (r.l. lobe/50)	Spleen (whole organ/50)
6	2.5×10^4	(2) neg. (4) pos.	2.5×10^4 1.0×10^2	1.1×10^4 2.5×10
6	2.5×10^5	pos.	1.7×10^2	6.0×10
6	2.5×10^6	pos.	0.5×10^2	3.0×10
6	0 (controls)	neg.	1.2×10^4	1.7×10^4

* No. of viable units per milliliter of nebulizer fluid.
† 300 tuberculin units intracutaneously, read after 24 hrs.
‡ Plate counts at 28 days after airborne challenge with about 100 infecting units of virulent tubercle bacilli (H37Rv) per animal.

Gross and microscopic examination of the lungs, mediastinal nodes, spleens, and livers of guinea pigs at 35 days after inhalation of these small numbers of living BCG organisms have revealed no abnormalities except for occasional and slight enlargement of the mediastinal nodes containing a few microscopic collections of epithelioid cells which harbor small numbers of acid-fast rods.

Evidence has been adduced that the development of tuberculin allergy and immunity after airborne exposure to BCG organisms under these conditions is dependent upon actual multiplication of the attenuated organisms in the guinea pig. Thus treatment of the animals with a sterilizing antibacterial agent, isoniazid, for 10 days after airborne exposure to large numbers of BCG organisms completely prevents the development of tuberculin hypersensitivity or immunity.

These results with the commercially available vaccine have been confirmed in other experiments under similar conditions with the stock laboratory strain BCG "D." On the other hand, in several experiments organisms of the BCG "T" strain have been ineffective in conferring tuberculin hypersensitivity or immunity under conditions calculated to provide for inhalation of as many as 300 to 500 potentially infecting units per guinea pig. Especially noteworthy is the fact that this strain is, nevertheless, quite effective in conferring immunity when it is introduced in customary dosage by the subcutaneous route. It is common experience in our laboratory that strains of tubercle bacilli lose infectivity or pathogenicity (or both) on repeated passage through Tween-albumin liquid medium. Thus the striking difference between the BCG "D" and "T" strains on inhalation indicates that the airborne infection route can provide a precisely quantitative means of defining the infectivity of different strains and cultures of attenuated tubercle bacilli.

The observations described in this report have important implications. (i) The consequences of inhalation of small numbers of living BCG organisms by human beings should be investigated. Mass airborne BCG immunization, under appropriate epidemiologic conditions, should have certain advantages over conventional methods. (ii) Possibilities are suggested of airborne immunization of experimental animals against some other types of respiratory tract infection with living attenuated parasites.

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7. When calculations are made from the known aerodynamic characteristics of this airborne infection apparatus (3), and on the assumption that each guinea pig inspires 3 liter/30 min, this infection rate corresponds well with the experience described by Lurie [*Am. Rev. Tuberc.* 61, 765 (1950)]—that is, one infective unit out of every three inhaled actually infects to produce a primary tuberculous lesion.
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24 June 1958

Cholinesterase in a Receptor

Abstract. Cholinesterase is found at the sites for mechanoelectric conversion of Pacinian corpuscles; its acetylcholine-splitting activity is of the same order of magnitude as that of the cholinesterase at neuromuscular junctions. The enzyme is not a typical acetylcholinesterase.

When a Pacinian corpuscle is pressed upon, a graded potential (generator potential) is produced inside the sense organ. Within certain limits, this potential is a linear function of the applied pressure. Although it is now clear that the generator potential is produced at the nonmyelinated nerve ending inside the corpuscle (*1*), nothing is known about the mechanisms which convert the deformation into the generator potential. From time to time it has been surmised that a substance like acetylcholine might be involved in the excitation of this and other receptors. In fact, a variety of mechanoreceptors are sensitive to applied acetylcholine (*2*, *3*). More direct evidence for participation of acetylcholine in reception, such as evidence that acetylcholine is present in the receptor, is lacking.

An early attempt to test for the presence of acetylcholine in Pacinian corpuscles gave negative results (*2*). There are, however, a considerable number of difficulties encountered in assaying acetylcholine in the corpuscle: the esterase is also likely to be present and, in addition, there are strong diffusion barriers (*4*). Any attempt to block the esterase by applying antiesterases from within or without the sense organ involves dealing with the diffusion barriers of multiple lamellae inside the capsule. An assay of the sense organ's cholinesterase, which is a very stable enzyme, seemed more promising. Although this may seem a priori a more indirect approach, the presence of a particular enzyme, namely acetylcholinesterase, in a tissue is in general a good indication that the corresponding substrate is there metabolized. This report deals with the nature, localization, and concentration of cholinesterase in the Pacinian corpuscle (*5*).

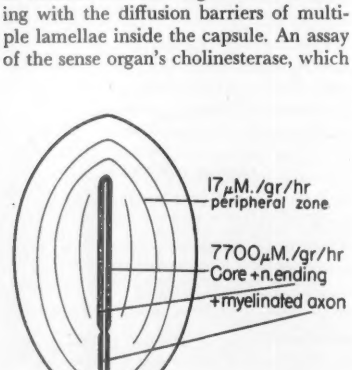

Fig. 1. Distribution of cholinesterase in a Pacinian corpuscle. The figures to the right indicate the amount of acetylcholine which is split in 1 hour by 1 g of the corresponding tissue of the sense organ. Note the very high cholinesterase activity around the nerve ending; this activity is of the same order of magnitude as that of a motor end plate of frog sartorius muscle.

Single corpuscles were obtained from the mesentery and the pancreas of the cat. They were freed by dissection from mesenteric and pancreatic tissue, and their axon was cut at the point where it emerges from the corpuscle. From 50 to 600 corpuscles, depending on the kind of experiment to be performed, were thus prepared for each assay. They were kept and homogenized in a refrigerated Krebs's solution. The cholinesterase activity of the homogenates was determined by Hestrin's technique (*6*). A few determinations were also made by the usual manometric technique; they gave essentially the same results.

Pacinian corpuscles were found to contain rather large amounts of cholinesterase. As averaged over 1060 corpuscles, a concentration of cholinesterase capable of splitting 16 mg of acetylcholine per hour, per gram of corpuscle tissue, was found. A single corpuscle of normal size contains a concentration of cholinesterase which hydrolyzes 1.6 μg of acetylcholine per hour. The enzyme in the corpuscle is not a typical acetylcholinesterase, for its rate of hydrolysis of butyrylcholine is approximately three times that of acetylcholine (at concentrations of from 4 to 5 μmole per milliliter of substrate known to be optimal for acetylcholine). Besides, the esterase does not show the clear optimum of substrate (acetylcholine) concentration which is characteristic of acetylcholinesterase (*7*). Instead, no sign of inhibition of enzyme activity is observed even with substrate concentrations raised to 0.1*M*, at which concentrations the activity of acetylcholinesterase would have become considerably depressed. On the other hand, the enzyme does not split any detectable amount of monobutyrine. It is therefore a cholinesterase, although not of the typical kind of acetylcholinesterase found in many excitable tissues (*7*, *8*).

Our most interesting observation was the uneven distribution of cholinesterase inside the structures of the corpuscle. By far the largest part of the enzyme appeared to be localized in the axon and ending, and in the thin hull of core structure which surrounds the ending. The remaining tissue of the corpuscle contains only little of the enzyme (Fig. 1). In these experiments, single corpuscles were prepared as described above, but, in addition, the "peripheral zone" of each corpuscle was separated by dissection from the "inner core" (*1*), which contains the nerve ending and has a stump of about 200 μ of myelinated axon attached to the latter. Both fractions of the sense organ were separately homogenized and tested for cholinesterase. It was found that the core fraction—that is, the nerve ending plus the myelinated stump plus the core—contains cholinesterase capable of splitting 1390 mg of acetylcholine per hour per gram. This provides the structures around the nerve ending with the ability to hydrolyze 0.7×10^9 molecules of acetylcholine per millisecond—a figure similar to that calculated (1.6×10^9) for a single end plate of frog sartorious muscle (*7*). The capsular fraction, on the other hand, which amounts to more than 99 percent of the corpuscle's mass, splits as little as 3 mg of acetylcholine per hour per gram.

Since the cholinesterase found is not a typical acetylcholinesterase, the question of the nature and function of the enzyme and its normal substrate remains to be elucidated. It is noteworthy, however, that the high concentrations of cholinesterase were found precisely around the nonmyelinated nerve ending, where also the generation of electric activity of the receptor has been shown to take place (*1*), whereas, on the other hand, the large peripheral capsular zone, which does not participate in mechanoelectric conversion (*1*), was found to contain only a negligible amount of the enzyme.

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D. MOLINS

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References and Notes

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5. The work reported in this study was supported by research grants from the National Institutes of Health, U.S. Public Health Service (B-1466-R1); the National Cystic Fibrosis Research Foundation; and the National Science Foundation. We take pleasure in thanking Dr. D. Nachmansohn of the biochemistry department, Columbia University, College of Physicians and Surgeons, for valuable suggestions and help.
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30 June 1958

Association Affairs

Programs Planned for the AAAS Washington, D.C., Meeting

Section and society programs in the social and economic sciences, history and philosophy of science, engineering, and agriculture, to be presented at the Washington meeting, are given here. Programs in mathematics, physics, chemistry, astronomy, geology and geography, the biological sciences, anthropology, and psychology have been previously announced.

Social and Economic Sciences

Section K. Two-session symposium: "Research Problems in the Social Sciences"; arranged by Donald P. Ray, National Academy of Economics and Political Science, Washington, D.C.; 28 and 29 Dec.

Part I, Joseph J. Spengler, Duke University, presiding. Papers by Kenneth E. Boulding, University of Michigan; Harold D. Lasswell, Yale University; and John W. Tukey, Princeton University.

Part II, Stuart A. Rice, Surveys and Research Corporation, Washington, D.C., presiding. Papers by Edward A. Schils, University of Chicago; Ralph W. Tyler, Center for Advanced Study in the Behavioral Sciences, Stanford, Calif.; and Harry Alpert, University of Oregon.

Contributed papers; 31 Dec.; arranged by Donald P. Ray, who will preside. Six papers will be presented.

American Political Science Association. Political Science Roundtable, jointly with the District of Columbia Political Science Association, cosponsored by Section K (Social and Economic Sciences); 27 Dec.; arranged by Howard R. Penniman, Georgetown University, who will preside. Papers by Karl Deutsch, Yale University, and William Y. Elliott, Harvard University and consultant to the Department of State. Discussants: Harold Lasswell, Yale University; David Z. Beckler, President's Scientific Advisory Committee; and Roger Hilsman, Library of Congress.

American Society of Criminology. Four-session symposium, cosponsored by the Association for the Psychiatric Treatment of Offenders, the Institute for Research on Crime and Delinquency, Character Underwriters, Inc., the New York Institute of Criminology, the New York Institute of Public Service Training, and the Society for the Scientific Study of Sex: "Controversial Areas in Twentieth Century Criminology"; arranged by a committee, Donal E. J. MacNamara, New York Institute of Criminology, chairman; 27 and 28 Dec.

Part I: "Crime and Punishment in Twentieth Century America"; John P. Kenney, American Society of Criminology and University of Southern California, chairman; Vernon Fox, Florida State University, discussion leader; and Michael J. DeLuca, New York Institute of Criminology, rapporteur. Papers by Howard B. Gill, American University; Henry Weihofen, University of New Mexico; Sara B. Ehrmann, American League to Abolish Capital Punishment; Michael J. Perry, Michigan State Penitentiary; and Barnard Schwartz, New York University.

Part II: "Crime in America"; Herbert Bloch, Brooklyn College, chairman; Marcel Frym, Hacker Foundation, discussion leader; and Lois Higgins, Crime Prevention Bureau, Chicago, Ill., rapporteur. Papers by Maj. Gen. Haydon Boatner, U.S. Army; Vernon Fox, Florida State University; Paul Weston, New York City Police Department, and George Eastman, Director of Public Safety, Pontiac, Michigan; John P. Kenney, University of Southern California; and Melitta Schmideberg, Association for the Psychiatric Treatment of Offenders, New York City.

Part III: "Sex, Sanity, and Society"; Robert Gault, editor, *Journal of Criminal Law, Criminology, and Police Science,* Evanston, Ill., chairman; Howard Gill, American University, discussion leader; and Canio L. Zarrilli, New York Institute of Criminology, rapporteur. Papers by Robert Veit Sherwin, Society for the Scientific Study of Sex; Lois Higgins, Crime Prevention Bureau, Chicago; Benjamin Karpman, editor, *Archives of Criminal Psychodynamics,* St. Elizabeth's Hospital, Washington, D.C.; Philip Q. Roche, Conshohocken, Pa.; and Dean Tasher, Norman Beatty Memorial Hospital, Westville, Ind.

Part IV: "Controversial Approaches to Crime and Criminals"; Donal E. J. MacNamara, New York Institute of Criminology, chairman; Peter Lejins, University of Maryland, discussion leader; and William Dienstein, Fresno State College, Calif., rapporteur. Papers by Joseph Edelman, Hypnotism Center, Inc., New York; Klara Roman, New School for Social Research, New York; Maude Moss Craig, New York City Youth Board; Peter Lejins; and Herbert Bloch, Brooklyn College.

Luncheon and address: "Crime and the Labor Movement," by the Honorable Patrick McNamara, United States Senate; 27 Dec.; Donal E. J. MacNamara, chairman. Followed by the presentation of a scroll to Dr. Robert Gault on the occasion of the 50th year of publication of the *Journal of Criminal Law, Criminology, and Police Science.*

American Sociological Society. Symposium, cosponsored by Section K (Social and Economic Sciences): "Sociological Studies in Mental Disorder"; arranged by Jerome K. Myers, Yale University; 29 Dec.; August B. Hollingshead, Yale University, and Jerome K. Myers, cochairmen. Papers by Ozzie G. Simmons, Harvard School of Public Health; Edgar F. Borgatta, Russell Sage Foundation, and Henry Meyer, New York University; Leo Srole, Cornell University and Yale University; and Selden D. Bacon, Yale University.

Symposium, cosponsored by Section K (Social and Economic Sciences): "Demographic and Sociological Aspects of Scientific Manpower"; 29 Dec.; arranged by Robert M. Dinkel, Guilford College, who will preside. Papers by Martin Trow, University of California; Howard S. Becker, Community Studies, Inc., Kansas City, Missouri; C. A. McMahon, Louisiana State University; William F. Ogburn, Florida State University; and Talcott Parsons, Harvard University.

American Statistical Association. Invited papers, jointly with the Econometric Society and Section K (Social and Economic Sciences): "Statistical Methods in the 1960 Census"; arranged by Ezra Glaser, National Analysts, Inc., Washington, D.C.; 30 Dec.; Peyton Stapp, U.S. Bureau of the Budget, chairman. Three papers will be presented.

Invited papers, jointly with the Econometric Society and Section K (Social and Economic Sciences): "Some Developments in Statistical Economics"; 30 Dec.; arranged by Ezra Glaser, who will act as chairman. Papers by David Rosenblatt, American University; and Stedman B. Noble, George Washington University.

Metric Association. Symposium: "Metric Implementation in Pharmacy"; 28 Dec.; J. T. Johnson, Metric Association,

presiding. Papers by Robert P. Fischelis, American Pharmaceutical Association; Ralph W. Ernsberger, Eli Lilly and Company; Harry E. Sagen, Abbott Laboratories; and Paul Bolton, Public Relations Foundation.

National Academy of Economics and Political Science. Symposium, jointly with the American Economic Association and Section K (Social and Economic Sciences), with the collaboration of the National Social Science Honor Society Pi Gamma Mu: "Major Problems of the American Economy"; arranged by Donald P. Ray, National Academy of Economics and Political Science; 27 Dec.; Edwin G. Nourse, Washington, D.C., presiding. Papers by Edward S. Shaw, Stanford University; D. Gale Johnson, University of Chicago; and Joseph J. Spengler, Duke University.

History and Philosophy of Science

Section L. Contributed papers; 28 Dec.; Carl B. Boyer, Brooklyn College, presiding.

Invited papers: "Science in Antiquity"; 29 Dec.; William H. Stahl, Brooklyn College, presiding. Papers by Edward Grant, Harvard University; Julian L. Huxley, Oxford University; Martin Levey, Temple University; and Derek J. Price, Institute for Advanced Study, Princeton, N.J.

Dinner and Vice-presidential address of Section L, jointly with the History of Science Society: "Mathematical Inutility and the Advance of Science," by Carl B. Boyer; 29 Dec.; Henry Guerlac, Cornell University, presiding.

Invited papers, jointly with the History of Science Society, cosponsored by the Society for the History of Technology: "History of Technology in America"; 30 Dec.; Carl W. Condit, Northwestern University, presiding. Papers by Eugene S. Ferguson, Smithsonian Institution; John B. Rae, Massachusetts Institute of Technology; E. Neal Hartley, Massachusetts Institute of Technology; and Max Jammer, Boston University.

History of Science Society. Invited papers: "Studies in Pre-Darwinian Evolution"; 29 Dec.; Conway Zirkle, University of Pennsylvania, presiding. Papers by Robert C. Stauffer, University of Wisconsin, and Loren C. Eiseley, University of Pennsylvania. Invited papers: "Problems and Studies in 19th Century Science"; 30 Dec.; Morris C. Leikind, Armed Forces Institute of Pathology, presiding. Papers by L. Pearce Williams, University of Delaware, and Nathan Reingold, National Archives.

Society for General Systems Research. Symposium: "Population Dynamics"; arranged by Richard L. Meier, University of Michigan; 29 Dec.; Kenneth E. Boulding, University of Michigan, chairman. Papers by Jerzy Neyman and Elizabeth L. Scott, University of California; Lawrence B. Slobodkin, University of Michigan; Mervyn L. Cadwallader, San Jose State College. Contributed papers; 29 Dec.; Kenneth Boulding, presiding.

Engineering

Section M. Four-session symposium: "National and International Aspects of Systems of Units in Coordinated Disciplines of Science and Technology"; arranged by a committee, Carl F. Kayan, Columbia University, chairman; 29 and 30 Dec.

Part I: "Measurement Units: Present Situation in the United States and Abroad"; Carl F. Kayan, presiding. Papers by George F. Hussey, American Standards Association; F. B. Silsbee, National Bureau of Standards; J. J. Moran, Kimble Glass Co.; E. L. Ruh, Esso Research and Engineering Co.; and R. D. Thompson, Taylor Instrument Co.; Chauncey D. Leake, Ohio State University; Irvine C. Gardner, National Bureau of Standards; and A. H. Hughes, Metric Committee, British Association for the Advancement of Science.

Part II: "Practices and Problems in Technology"; Ralph A. Sherman, Battelle Memorial Institute, presiding. Pa-

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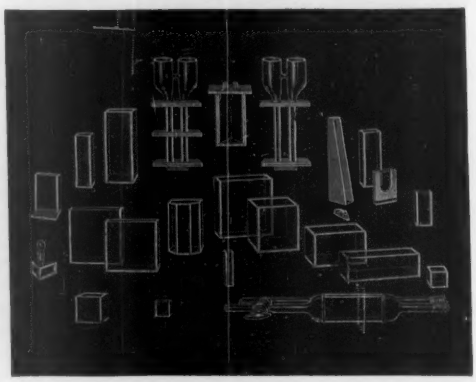

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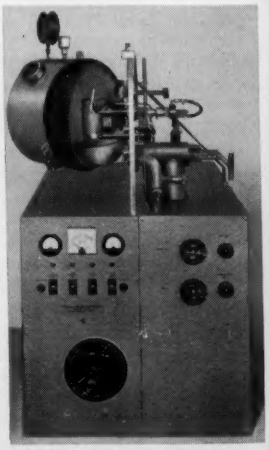

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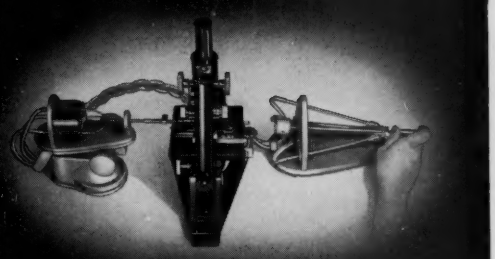

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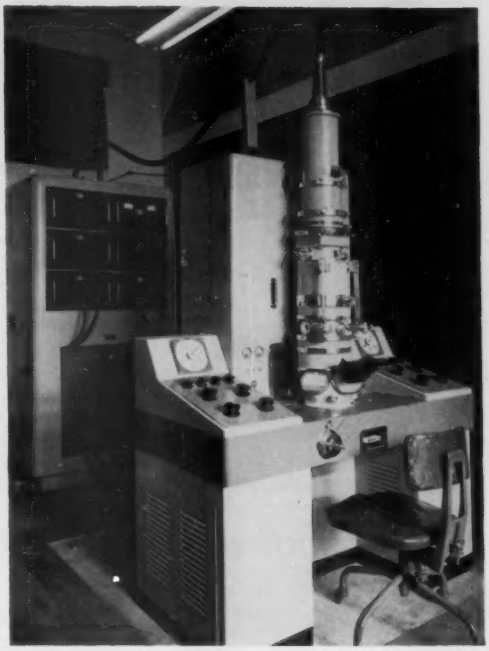

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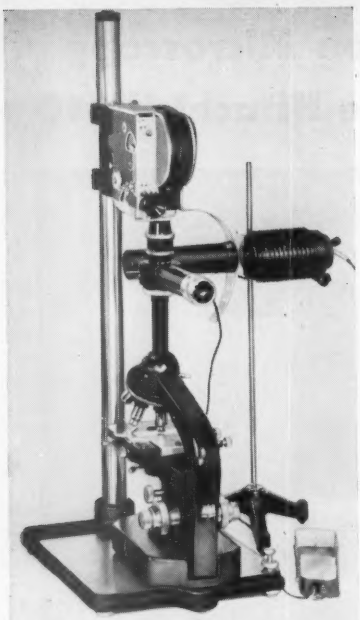

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Part III: "Practices and Problems in Industry, Commerce, and Defense"; Robert J. Painter, American Society for Testing Materials, Philadelphia, presiding. Papers by Erwin G. Loewen, Taft-Pierce Co.; Roy P. Trowbridge, General Motors Co.; Allen Latham, Jr., Arthur D. Little, Inc.; James F. Young, General Electric Company Engineering Laboratory, Schenectady, N.Y.; Harry C. Trelogan, U.S. Department of Agriculture; and John R. Townsend, Office of the Secretary of Defense.

Part IV: "Proposals for Unification and Simplification"; Clarence E. Davies, United Engineering Trustees, Inc., New York, presiding. Papers by P. G. Belitsos, General Electric Company; Matts Bäckström, Royal Institute of Technology, Stockholm, Sweden; Ralph A. Sherman, Battelle Memorial Institute; G. Ruppel, Verein Deutscher Ingenieure, Düsseldorf, Germany; Ralph W. Ernsberger, Eli Lilly and Co.; Carl C. Chambers, University of Pennsylvania; E. J. Lefevre, Queen Mary College, London; G. Lorentzen, Institute of Technology, Trondheim, Norway; Peter Grassmann, Federal Institute of Technology, Zurich, Switzerland; and Ernst Schmidt, Institute of Technology, Munich, Germany.

American Society of Photogrammetry. Two-session symposium, cosponsored by Sections B (Physics), D (Astronomy), E (Geology and Geography), F (Zoological Sciences), H (Anthropology), M (Engineering), N (Medical Sciences), P (Industrial Science), and O (Agriculture): "Photogrammetry in Science"; arranged by Richard G. Ray, U.S. Geological Survey; 29 Dec.; David Landen, U.S. Geological Survey, presiding.

Part I: papers by Paul Baker, Pennsylvania State University; William Francis Thompson and Dan Wiley Clancy, Fisheries Research Institute, University of Washington; J. Thomas Dutro, Jr., U.S. Geological Survey, and Ralph M. Berry, University of Michigan.

Part II: papers by Hugh Bradner, University of California; S. Vasilevskis, Lick Observatory; R. A. Laflamme, Massachusetts Institute of Technology; Austin Hasel and Earl J. Rogers, U.S. Forest Service; and Alfred O. Quinn, Aero Service Corporation.

Instrument Society of America. Symposium: "Instrumentation of Precision Measurements"; 30 Dec.; arranged by Orval L. Linebrink, Battelle Memorial Institute, who will preside. Papers by L. B. Macurdy, H. A. Bowman, and Hilding E. Elmer, National Bureau of Standards; W. J. Darmody, Sheffield Corporation; A. O. McCoubrey, National Company, Inc.; and Sumner B. Irish, Princeton University.

Agriculture

Section O. Four-session symposium, cosponsored by Section E (Geology and Geography), American Geophysical Union, American Meteorological Society, American Society for Horticultural Science, American Society of Agricultural Engineers, American Society of Agronomy, American Society of Civil Engineers, Gamma Sigma Delta, Geological Society of America, Society of American Foresters, and the Soil Conservation Society of America: "Water and Agriculture"; arranged by Roy D. Hockensmith, Soil Conservation Service, U.S. Department of Agriculture; 29 and 30 Dec.

Part I: "Water for the Future"; D. A. Williams, Soil Conservation Service, U.S. Department of Agriculture, presiding. Papers by Edward A. Ackerman, Carnegie Institution of Washington; Clarence A. Davis, Washington, D.C.; Carl B. Brown, Soil Conservation Service; and R. L. Nace, U.S. Geological Survey. Discussion leader: Bernard Frank, Forest Service, U.S. Department of Agriculture.

Part II: "Water Sources"; H. J. Sloan, University of Minnesota, presiding. Papers by William C. Ackermann, Illinois State Water Survey Division, Urbana; Howard T. Orville, Beckman and Whitley, Inc.; C. H. M. Van Bavel, Agricultural Research Service; and G. L. Barger, U.S. Weather Bureau. Discussion leader: Vincent J. Schaefer, The Munitalp Foundation, Inc.

Part III: "Water Planning and Use"; Roy L. Lovvorn, North Carolina Agricultural Experiment Station, presiding. Papers by Cecil H. Wadleigh, Agricultural Research Service, U.S. Department of Agriculture; Herbert C. Storey, Forest Service, U.S. Department of Agriculture; Wayne D. Criddle, Utah State Engineer; and William I. Palmer, Bureau of Reclamation, Washington, D.C. Discussion leader: William G. McGinnies, Central States Forest Experiment Station, Columbus, Ohio.

Part IV: "Water Control"; Louis M. Thompson, Iowa State College, presiding. Papers by T. W. Edminster, Agricultural Research Service, U.S. Department of Agriculture; F. L. Timmons and D. L. Klingman, Agricultural Research Service, U.S. Department of Agriculture; G. Earl Harbeck, Jr., U.S. Geological Survey, Denver; and C. B. Tanner, University of Wisconsin. Discussion leader: Waldo E. Smith, American Geophysical Union.

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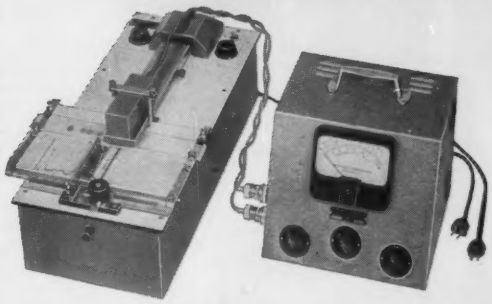

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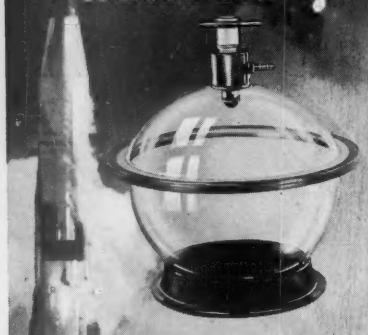

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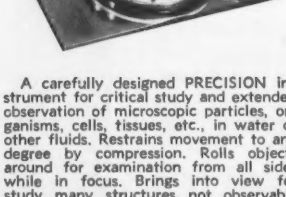

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Meetings

American Nuclear Society

L. R. Hafstad, research vice president of the General Motors Corporation, and Walker L. Cisler, president of the Detroit Edison Company, will serve as general chairmen of the 1958 annual meeting of the American Nuclear Society, which is to be held at the Sheraton-Cadillac Hotel in Detroit, 8–10 December. The meeting will draw 1400 engineers and scientists, including representatives from European and South American countries.

Highlight of the meeting will be a report on the United Nations Second International Conference on the Peaceful Use of Atomic Energy. Twenty-four technical sessions have been arranged, featuring approximately 175 papers covering all phases of nuclear science and technology. Alfred Amorosi, Technical Director of Atomic Power Development Associates, Inc., has been appointed local program chairman. He reports that field trips are being planned to the Enrico Fermi Atomic Power Plant near Monroe, Mich., and to the University of Michigan Phoenix Memorial Project, including the Ford Test Reactor on the north campus at Ann Arbor.

Ice Age History

A paper to be presented at the December meeting of the AAAS in Washington, D.C., will include a proposal for a wholly new concept of ice age history. Full treatment of this subject will be presented in the future, but it is sufficient to announce at this time that abundant new data have been collected at the department of geography of Clark University during the present International Geophysical Year.

1) Deposits formerly attributed to four or five separate Pleistocene glaciations, both in America and in Europe, are deposits of a single glaciation.

2) Limits of the glaciation in the Missouri-Mississippi-Ohio drainage basin are marked by southern borders of the so-called Nebraskan, Kansan, and Illinoian till sheets, and on Long Island, by the terminal moraine.

3) At the climax of glaciation a depressed state of the earth's crust under the icecap centering in the region of Hudson Bay permitted waters of the lowest position of Glacial sea level to form estuaries penetrating to the ice border in the Mississippi embayment and in the Columbia River basin. These synchronous marine stages, known as the "Leverett Sea," were kept fresh by large outflow, like headwaters of the Baltic today.

4) Normal retreat of the borders of

the icecap permitted the Leverett Sea to expand into valleys of southern New England and the lower Hudson valley, and, in the Mississippi basin, over the whole area of the so-called Nebraskan, Kansan, and Illinoian glaciations, so that an immense ice-marginal body of water was formed, extending from Ohio to Montana and from the Gulf of Mexico to the Wisconsin driftless area. Iceberg-rafted erratic stones and boulders became grounded on the submerged topography of northern Kentucky, southwestern Missouri, and eastern Iowa (the so-called "Iowan" stage). Gumbo clays, until recently interpreted to be weathered tills, were deposited within the expanse of the sea-level waters, along with drift-wood and other organic material heretofore interpreted to be "interglacial deposits." Immense kames and eskers were built by subglacial rivers emerging from beneath the ice border under water.

5) When the edge of the icecap had melted and calved back to the so-called "Wisconsin" ice-border position, the relief from ice weight inaugurated a great upwarping movement of the earth's crust (called the Hubbard uplift), which lifted the entire glaciated area from the Atlantic to the Pacific. As the land rose and assumed directions of slope away from the ice, the ice-frontal estuaries of the Leverett Sea drained away and were replaced by the post-Glacial Ohio, Mississippi, Missouri, and Columbia rivers, thereby originating such features as the submerged channel of the Hudson River and the channeled scablands of the state of Washington. The Hubbard uplift took place shortly after New Haven, Connecticut, was uncovered, shortly before Indianapolis was uncovered, and long before the uncovering of the Glacial Great Lakes. At the end of the movement the ice border was almost all on dry land, on which thereafter it formed subaerial outwash plains, valley trains, and successive moraines. Drumlins which made their appearance during the ensuing retreat had been generated by land movement under the ice; dissection of many of the older submergence deposits commenced; and conditions became ideal for widespread loess deposition. The contrast in appearance of submergence deposits and deposits formed after the uplift partly explains how the concept of "Older" and "Last" glaciations came about.

6) During the Hubbard uplift the outer boundary of upwarping shifted iceward from a Hubbard hinge line of undetermined location outside the limits of glaciation to the Whittlesey hinge line in the Erie-Michigan basins. At the end of the Hubbard uplift the Leverett marine-water plane in the Mississippi embayment was left in the upwarped position it has today—submerged about 450 feet below present sea level in Louisiana,

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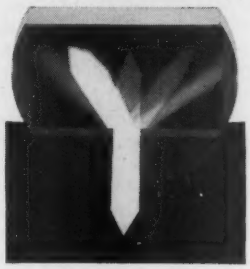

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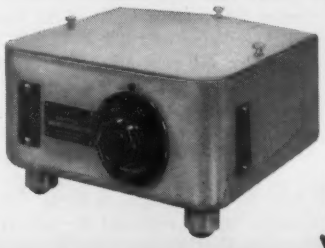

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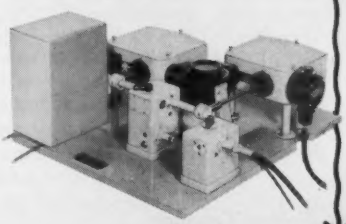

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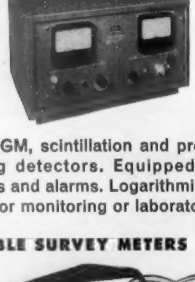

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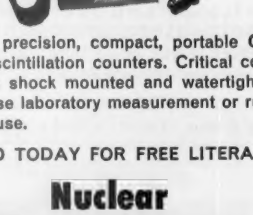

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raised 540 feet above present sea level in southeastern Missouri, and raised over 800 feet in northwestern Illinois.

7) Further recessional events followed essentially the present historical concepts, with a Glacial Great Lakes stage, additional marine stages (the DeGeer in Maine and in Puget Sound and the Champlain in the St. Lawrence), and iceward migration of hinge line activity from the Whittlesey to the Algonquin hinge line, as upwarping continued.

8) Reduction of the ice age to "unity" shortens geological history and nullifies the present meaning of the terms *Nebraskan, Kansan, Illinoian, Wisconsin,* and the several *"interglacials."* Ice age history appears to have been influenced or regulated far less by climatic changes and moraine building than by the intermittent character of the great land movements which continue to the present. There is urgent need in America and Europe for a tectonic chronology of the ice age, based on transatlantic correlation of marine stages and simultaneous timing of the continental uplifts.

RICHARD J. LOUGEE
Clark University,
Worcester, Massachusetts

Clinical Chemistry

More than 200 clinical chemists attended the recent meeting of the American Association of Clinical Chemists in Iowa City, 4–6 September. The program included a symposium on the applications of quality control to clinical laboratories and a series of 46 papers dealing with various aspects of clinical chemistry.

In the presidential address, Oliver Gaebler briefly reviewed the history of the AACC; then he pointed out that contact with scientists in other disciplines is the best way for stimulating not only clinical chemistry, but the individual clinical chemist.

A highlight of the meeting was the presentation of the Bischoff Award to Marschelle H. Power, senior consultant in biochemistry at the Mayo Clinic, "for outstanding contributions to clinical chemistry." The award, which is sponsored by the Ames Company of Elkhart, Ind., consists of a medal, a citation, and an honorarium of $500. The 11th annual meeting will be held in Cleveland, Ohio, in the fall of 1959.

Biology Teaching

The second annual meeting of the Association of Midwest College Biology Teachers was held at Western Illinois University (Macomb), 10–11 October. More than 200 representatives of some 90 colleges and universities attended. The primary purpose of the organization is to seek and develop ways of improving the teaching of biology at all levels of instruction.

Most of the meeting was devoted to seven discussion sections. Among the topics considered were the nature of the first course in biology, the biology-major program, the preparation of high school biology teachers, the education requirements for high school teachers, the graduate preparation of college biology teachers, laboratory and field work in the first course, and special readings for biology majors. Two addresses were given: one by W. H. Bragonier, Iowa State College, "Science Education and You," and the other by James F. Crow, University of Wisconsin, "What Is a Gene?"

Willis H. Johnson of Wabash College succeeds Leland P. Johnson of Drake University as president of the association.

Forthcoming Events

December

18–20. American Physical Soc., Los Angeles, Calif. (K. K. Darrow, APS, Columbia Univ., New York 27.)

26–31. American Assoc. for the Advancement of Science, annual, Washington, D.C. (R. L. Taylor, AAAS, 1515 Massachusetts Ave., NW, Washington 5.)

The following 47 meetings are being held in conjunction with the AAAS annual meeting.

AAAS Committee on the Social Aspects of Science (C. D. Leake, Ohio State Univ. College of Medicine, Columbus, Ohio). 27 Dec.

AAAS Cooperative Committee on the Teaching of Science and Mathematics (J. W. Buchta, Univ. of Minnesota, Minneapolis, Minn.). 28 Dec.

Academy Conf. (J. A. Yarbrough, Meredith College, Raleigh, N.C.). 27–28 Dec.

Alpha Epsilon Delta (M. L. Moore, 7 Brookside Circle, Bronxville, N.Y.). 27 Dec.

American Assoc. of Clinical Chemists (Miss E. G. Frame, Clinical Center, Natl. Institutes of Health, Bethesda 14, Md.). 29–30 Dec.

American Assoc. of Scientific Workers (R. J. Rutman, 6331 Ross St., Philadelphia 44, Pa.).

American Astronautical Soc. (R. Fleisig, 58 Kilburn Rd., Garden City, N.Y.). 27–30 Dec.

American Geophysical Union (W. E. Smith, AGU, 1515 Massachusetts Ave., NW, Washington 5).

American Meteorological Soc. (K. Spengler, 3 Joy St., Boston, Mass.).

American Nature Soc. (S. Mulaik, Biology Dept., Univ. of Utah, Salt Lake City). 26–30 Dec.

American Physiological Soc. (F. A. Hitchcock, Ohio State Univ., Columbus).

American Political Science Assoc. (E. M. Kirkpatrick, APSA, 1726 Massachusetts Ave., NW, Washington, D.C.). 27 Dec.

American Psychiatric Assoc. (L. J.

West, Univ. of Oklahoma School of Medicine, Oklahoma City 4). 27–28 Dec.

American Soc. of Criminology (D. E. J. MacNamara, Dean, New York Inst. of Criminology, Inc., 40 E. 40 St., New York 16). 27–28 Dec.

American Soc. of Naturalists (J. Schultz, Inst. for Cancer Research, Philadelphia, Pa.).

American Soc. of Photogrammetry (R. G. Ray, U.S. Geological Survey, Washington 25). 29 Dec.

American Soc. of Zoologists (G. Moment, Dept. of Biology, Goucher College, Towson, Baltimore 4, Md.). 27–29 Dec.

American Sociological Soc. (K. Davis, Inst. of International Studies, Univ. of California, Berkeley 4). 29 Dec.

Association of American Geographers, Middle Atlantic Div. (J. E. Guernsey, 9707 Parkwood Dr., Bethesda, Md.). 29 Dec.

Association for Computing Machinery (J. Douglas, Mathematics Dept., Rice Inst., Houston, Tex.).

Astronomical League (Miss G. C. Scholz, 410 Mason Hall Apts., Alexandria, Va.). 26 Dec.

Biometric Soc. (J. Cornfield, Johns Hopkins Univ., Baltimore, Md.). 30 Dec.

American Statistical Assoc. (E. Glazer, 305 George Mason Dr., Falls Church, Va.). 30 Dec.

Conference on Scientific Communication Problems (G. L. Seielstad, Applied Physics Lab., Johns Hopkins Univ., Silver Spring, Md.) 28–30 Dec.

Conference on Scientific Manpower (T. J. Mills, National Science Foundation, Washington 25). 30 Dec.

Ecological Soc. of America (D. E. Davis, Johns Hopkins Univ., School of Hygiene, Baltimore, Md.).

History of Science Soc. (M. C. Leikind, 1334 Aspen St., NW, Washington 12). 29 Dec.

Instrument Soc. of America (O. L. Linebrink, Battelle Memorial Inst., Columbus, Ohio). 30 Dec.

International Geophysical Year (H. Odishaw, National Acad. of Sciences, Washington 25). 29–30 Dec.

Junior Scientists Assembly (K. C. Johnson, Supervising Director of Science, District of Columbia Public Schools, Woodrow Wilson High School, Washington 16). 27–28 Dec.

Metric Assoc. (J. T. Johnson, 694 W. 11 St., Claremont, Calif.).

National Acad. of Economics and Political Science (D. P. Ray, Hall of Government, George Washington Univ., Washington, D.C.). 27 Dec.

National Assoc. of Biology Teachers (P. Klinge, Jordan Bldg., Indiana Univ., Bloomington). 26–30 Dec.

National Assoc. for Research in Science Teaching (E. S. Obourn, U.S. Office of Education, Washington 25). 26–30 Dec.

National Assoc. of Science Writers (J. Billard, U.S. News and World Report, Washington, D.C.).

National Geographic Soc. (W. R. Gray, NGS, 16 and M Sts., NW, Washington 6). 30 Dec.

National Science Teachers Assoc. (W. A. Kilgore, District of Columbia Teachers College, Washington 9). 26–30 Dec.

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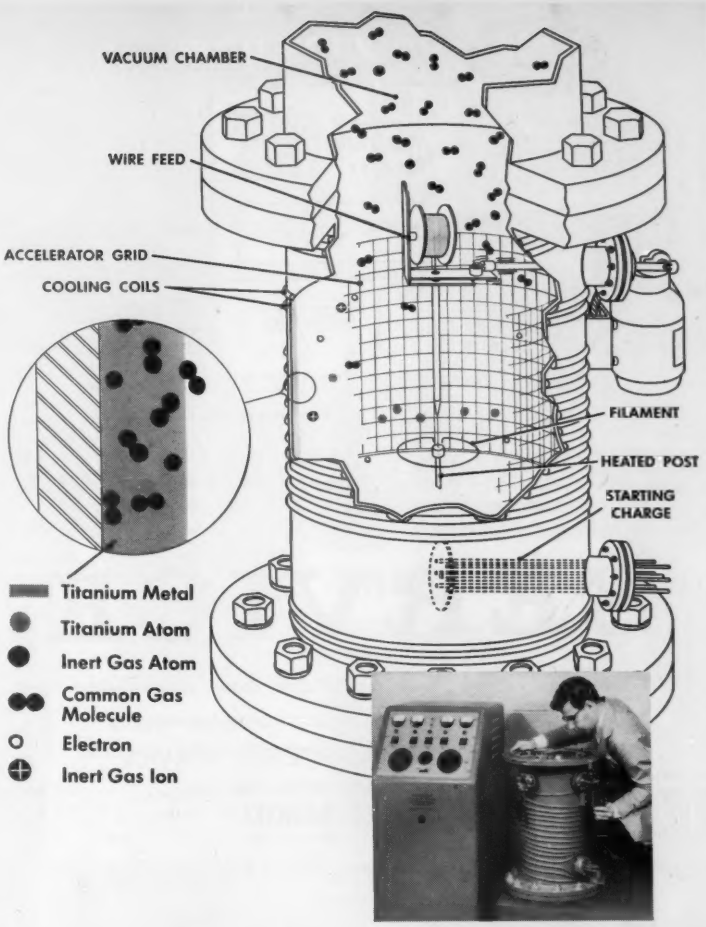

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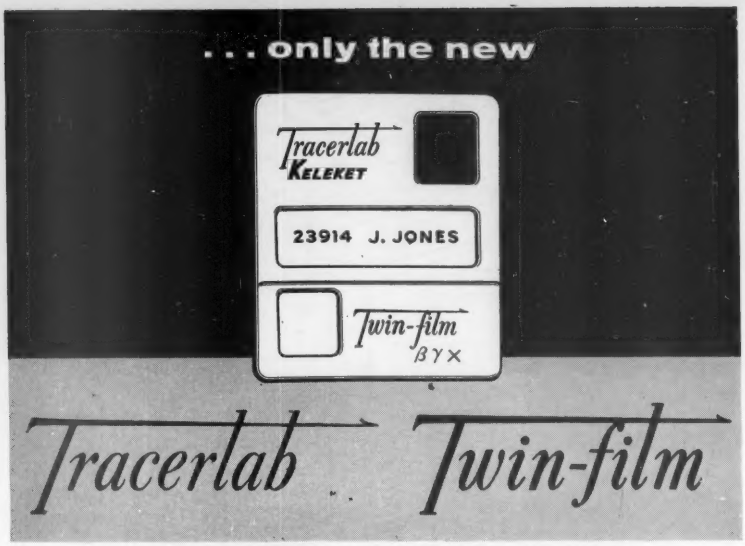

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Philosophy of Science Assoc. (C. W. Churchman, Case Inst. of Technology, Cleveland, Ohio).

Pi Gamma Mu (Mrs. Effie B. Urqhart, Winfield, Kan.).

Scientific Research Soc. of America (D. B. Prentice, 56 Hillhouse Ave., New Haven 11, Conn.).

Sigma Delta Epsilon (Mrs. V. L. Blackford, 2630 Adams Mill Rd., NW, Washington 10). 26–30 Dec.

Society for General Systems Research (R. L. Meier, Mental Health Research Inst., Univ. of Michigan, Ann Arbor). 29 Dec.

Society for Industrial Microbiology, Washington section (W. N. Ezekiel, Bureau of Mines, Washington 25). 27–28 Dec.

Society of the Sigma Xi (T. T. Holme, 56 Hillhouse Ave., New Haven 11, Conn.). 29 Dec.

Society of Systematic Zoology (G. W. Wharton, Dept. of Zoology, Univ. of Maryland, College Park). 26–30 Dec.

United Chapters of Phi Beta Kappa (C. Billman, 1811 Q St., NW, Washington, D.C.). 27 Dec.

Washington Acad. of Sciences (G. W. Irving, ARS, U.S. Dept. of Agriculture, Washington 25).

27–29. American Economic Assoc., Chicago, Ill. (J. W. Bell, AEA, Northwestern Univ., Evanston, Ill.)

27–29. Econometric Soc., Chicago, Ill. (R. Ruggles, Box 1264 Yale Station, Yale Univ., New Haven, Conn.)

27–30. American Folklore Soc., New York, N.Y. (MacE. Leach, AFS, Univ. of Pennsylvania, Philadelphia, Pa.)

28–30. Archaeological Inst. of America, Cincinnati, Ohio. (L. A. Campbell, AIA, Dept. of Classics, Brooklyn College, Brooklyn, N.Y.)

29–30. National Council of Teachers of Mathematics, New York, N.Y. (M. H. Ahrendt, NCTM, 1201 16 St., NW, Washington 6.)

28–30. Western Soc. of Naturalists, Seattle, Wash. (J. P. Harville, San Jose State College, San Jose 14.)

January

7–9. Northeastern Weed Control Conf., 13th annual, New York, N.Y. (E. R. Marshall, Carbide & Carbon Chemical Co., New York, N.Y.)

12–14. Reliability and Quality Control, 5th natl. symp., Philadelphia, Pa. (W. T. Sumerlin, Philco Corp., 4700 Wissahickon Ave., Philadelphia 44.)

20–22. American Mathematical Soc., annual winter, Philadelphia, Pa. (E. G. Begle, Leet Oliver Hall, Yale Univ., New Haven, Conn.)

21–22. American Group Psychotherapy Assoc., 3rd annual institute, New York, N.Y. (C. Beukenkamp, Public Relations Chairman, 993 Park Ave., New York 28.)

22–23. Mathematical Assoc. of America, 42nd annual, Philadelphia, Pa. (H. M. Gehman, MAA, Univ. of Buffalo, Buffalo 14, N.Y.)

23–24. American Group Psychotherapy Assoc., 16th annual conf., New York, N.Y.

(C. Beukenkamp, Public Relations Chairman, 993 Park Ave., New York 28.)

26–29. American Meterological Soc., New York, N.Y. (K. C. Spengler, AMS, 3 Joy St., Boston 8, Mass.)

26–29. American Soc. of Heating and Air Conditioning Engineers, 65th annual, Philadelphia, Pa. (W. M. Vidulich, ASHACE, 62 Worth St., New York 13.)

26–29. Institute of the Aeronautical Sciences, 27th annual, New York, N.Y. (IAS, 2 E. 64 St., New York 21.)

27–30. Society of Plastics Engineers, Inc., 15th annual tech. conf., New York, N.Y. (L. A. Bernhard, SPE, 65 Prospect St., Stamford, Conn.)

28–29. Nuclear Fuel Elements, 1st intern. symp., New York, N.Y. (H. H. Hausner, 1st Intern. Symp. on Nuclear Fuel Elements, 730 Fifth Ave., New York 19.)

28–31. American Physical Soc., annual, New York, N.Y. (E. R. Fitzgerald, Dept. of Physics, Pennsylvania State Univ., University Park.)

29–31. Western Soc. for Clinical Research, 12th annual, Carmel-by-the-Sea, Calif. (W. N. Valentine, Office of the Secretary, Univ. of California Medical Center, Department of Medicine, Los Angeles 24.)

February

1–6. American Inst. of Electrical Engineers, winter general, New York N.Y. (N. S. Hibshman, 33 W. 39 St., New York 18.)

9–11. Nature of Coal, symp., Bihar, India. (Director, Central Fuel Research Inst., P. O. Fuel Research Inst., Dhanbad District, Bihar.)

12–13. Solid State Circuits Conf., Philadelphia, Pa. (A. B. Stern, General Electric Co., Bldg. 3, Syracuse, N.Y.)

14. Short Range Navigation Aids., Montreal, Canada. (Intern. Civil Aviation Organization, Maison de l'Aviation Internationale, Montreal.)

15–19. American Inst. of Mining, Metallurgical, and Petroleum Engineers, annual, San Francisco, Calif. (E. O. Kirkendall, AIME, 29 W. 39 St., New York 18.)

16–19. Problems in Field Studies in Mental Disorders, intern. work conf., New York, N.Y. (J. Zubin, American Psychopathological Assoc., 722 W. 168 St., New York 32.)

20–21. Epidemiology in Mental Disorders, annual meeting of the American Psychopathological Assoc., New York, N.Y. (J. Zubin, APA, 722 W. 168 St., New York 32.)

26–28. Genetics and Cancer, 13th annual symp. on fundamental cancer research, Houston, Tex. (Editorial Office, Univ. of Texas, M. D. Anderson Hospital and Tumor Inst. Texas Medical Center, Houston 25.)

27–1. National Wildlife Federation, 23rd annual convention, New York, N.Y. (NWF, 232 Carroll St., NW, Washington 12.)

March

1–5. Gas Turbine Power Conf., Cincinnati, Ohio. (O. B. Schier, ASME, 29 W. 39 St., New York, N.Y.)

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Equipment

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■ INVERTER provides a square-wave output at 115 v, 400 cy/sec, at currents up to 750 ma. Input is 26 v d-c (±5 percent). Units can operate at temperatures up to 85°C. A filter is available to provide semisoidal output. (Power Sources Inc., Dept. 465)

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■ STRAIN GAGE RECORDING SYSTEMS for balancing, controlling, scanning, and recording output of 24 to 96 gages are available in 24-channel modules. Strain values are recorded on multipoint, strip-chart recorders. Individual gage-factor and range-selector controls are provided for each channel. Polarity is automatically indicated. Each module includes a regulated power supply and a programmer. (B & F Instruments, Inc., Dept. 470)

■ PRESSURE TRANSDUCER is of the double-coil, variable-reluctance type; a flat diaphragm is used as the pressure-sensing element. Pressure range is adjustable by a factor of 2 or more. Units are interchangeable without change in output. Output is 0.3 v/v over a carrier frequency range from 400 cy/sec to 70 kcy/sec. (Yuba Consolidated Industries, Inc., Dept. 491)

■ TRANSISTOR PREAMPLIFIERS have input impedance of 1 megohm and output impedance of 600 ohm. Gain is 20 db. Equivalent input noise is 10 μv; frequency range is 100 to 80,000 cy/sec. The amplifiers are available in cylindrical waterproof models or in rectangular splashproof models. (Chesapeake Instrument Corp., Dept. 496)

■ SAMPLING SWITCH is characterized by a closure time of the order of 40 μsec and a contact-break time less than 20 μsec. Precious-metal contacts of the device are mounted in barrel-stave fashion around the drive shaft and are actuated by a rotating air jet that strikes them in rapid succession. The movable contact remains in the deflected closure position until the air jet has passed. A typical model has 45 contact pairs and operates at a sampling speed of 20 rev/sec. (Norman Hardy Associates, Dept. 495)

■ GEAR BOX is adjustable to provide gear reductions from 1 : 1 to 3125 : 1 for use in servo and instrument equipments. Gears are AGMA precision 1 or better. Models with zero backlash are available. Dimensions are 2.875 in. in diameter by 1.090 in. long. (Precision Mechanisms Corp., Dept. 497)

■ DUAL-KEYBOARD TYPEWRITER provides one keyboard of scientific and mathematical characters. The two keyboards are adjusted so that the scientific symbols of one fall accurately into place on the script typed by the other. A total of 180 characters are provided. (Imperial Typewriter Co., Ltd., Dept. 489)

■ MEDICAL SLIDE RULE, 2 ft long, acts as a prompter or reminder if fed with symptom information. Approximately 80 symptom strips are stored on the back of the slide rule, and approximately 340 disease categories are listed on one side of the front. From one to six symptom strips can be inserted under a window. Where lines of these come together, they can be read off against the disease by an arrowed line that slides above the window. (Blundell Rules Ltd., Dept. 484)

■ INFRARED DETECTOR is a lead selenide cell capable of responding to radiation of 4.5 μ wavelength at room temperature with time constant of less than 10 μsec. The range of sensitivity can be extended to 5 μ by cooling to Dry Ice temperature. At the lower temperature, the time constant is increased to above 20 μsec. Practically any configuration is said to be feasible with minimum-size sensitive area of 0.25 mm². (Eastman Kodak Co., Dept. 488)

■ BEAM-SWITCHING TUBE TESTER will test both statically and dynamically each of the beam-switching tube's ten constant-current output positions; the stability of the electron beam when formed at a given position; and the characteristics of the high-impedance switching element of the tube. Plug-in adapters permit testing of seven types of tubes. Built-in meters allow direct measurement of parameters. Neon lights indicate beam position. (Burroughs Corp., Dept. 502)

JOSHUA STERN
National Bureau of Standards

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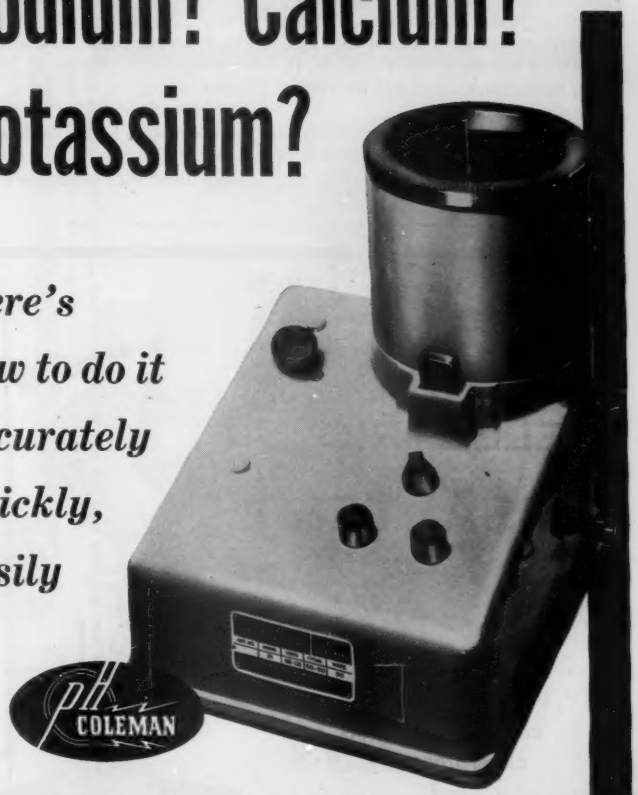

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(*Continued from page 1246*)

a vowel to provide a pronounceable syllable. The sequence of vowels is obvious, including the single irregularity; the sequence of consonants is easily fixed by the mnemonic "ankers," although the reason for it, if any, I have forgotten. At any rate, the sounds were thought to be readily discernible. Since "no" is an obvious representation of zero, one counts: "na, ne, ni, ko; ka, ke, ki, ro; ra, re, ri, so; sa, se, si, nano, . . ." and the rest is surely obvious.

It was recognized long ago that the same numeral "6," for example, can represent six, sixty, six hundred, . . . , or six-tenths, . . . , depending on its position within a sequence of numerals; indeed, it is not uncommon to read "six-five-one" instead of "six hundred and fifty-one." It should be equally obvious that "no-point-sa-ri" should be a perfectly acceptable and unambiguous rendering of "00. 1101, 1011." The system is therefore logically complete as far as integers and binary fractions are concerned. For other fractions, a simple use of "over" is sufficient.

It is with no little regret that I report that although both Flanders and I (but especially he) practiced assiduously for some time our "no-na" arithmetic, and although we acquired a modicum of skill in addition, nevertheless we failed miserably with multiplication. The decimal grooves were too deeply sunk in our aging cortices, and we finally gave it up as a bad job. But if I can ever catch an innocent, unsuspecting 6-year-old—a grandchild, perhaps—when his parents are not looking, I hope to show that he can become an arithmetical polyglot without half trying.

A. S. Householder
Oak Ridge National Laboratory, Oak Ridge, Tennessee

The requirements for oral communication of magnitudes are not the same as those for checking or transcribing numbers. An example will make this clear. To communicate the number 651000 one might call out "six-five-one-oh-oh-oh," and for checking purposes this is common practice. As Householder points out, the listener, on hearing the "six," does not know whether its significance is 60, 600, 6000, and so on. He has no information about magnitude until the decimal point is suddenly explicitly or implicitly reached, at which time he must have counted the number of digits expressed and have retained in his memory the digits of significance to him. If this were an easy task, words like *hundred, thousand,* and *million* would not be needed. Many users of computers have used a hexadecimal number system that adds the letters, a, b, c, d, e, and f to the decimal symbols already available. For checking binary numbers this system or that described by Householder are quite adequate.

Two requirements must be met by a system of names for communication of magnitudes: (i) The speaker and the listener must be free to express or accept as much or as little precision as desired. (ii) The most significant information must be communicated first. It should be borne in mind that numbers like 256 or 512 are round numbers in the binary system. To become conversant with binary magnitudes one must be able to express, for example, the information that a given vacuum tube functions properly with about "hi" volts on the plate or that the population of the United States is approximately "dagxi."

Real usefulness of the ability to communicate magnitudes by means of binary numbers, whether for pedagogic purposes or otherwise, can only be demonstrated experimentally. The response by educators to the publication of my proposal suggests that such experiments will soon be made. To encourage uniformity among experimenters who may need to extend the system, I have assigned the terms "lu = 2^{12}," "pro = 2^{16}," "ti = 2^{20}" and "xi = 2^{24}."

Joshua Stern
National Bureau of Standards, Washington, D.C.

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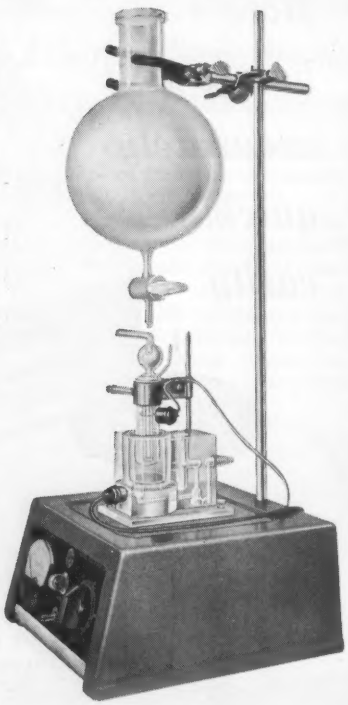

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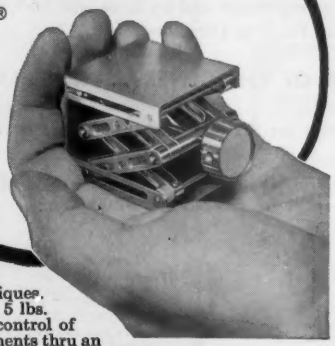

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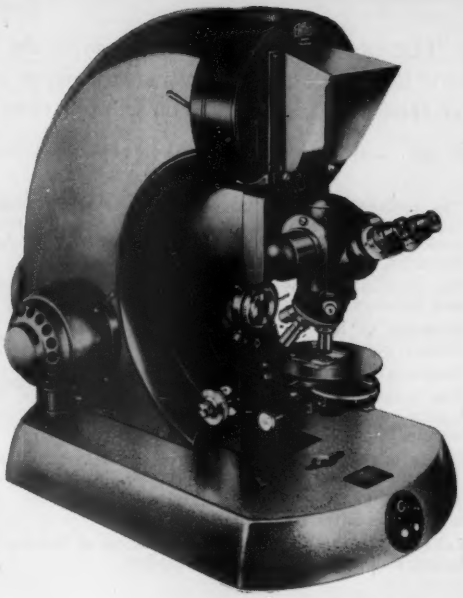

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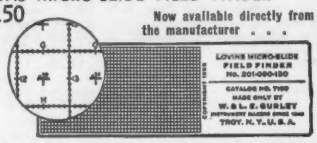

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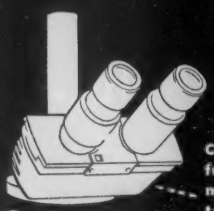

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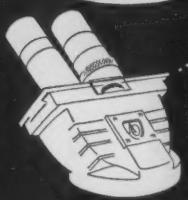

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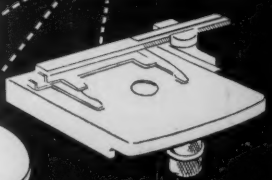

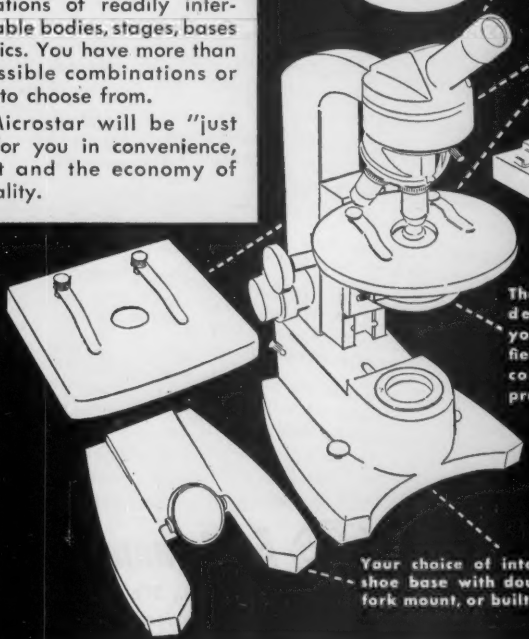

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